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ABSTRACT

This report is one of a series of disciplinary planning studies carried out by the Advisory Committee on Academic Planning of the Council of Ontario Universities. The emphasis of the report is on forward planning, and it is hoped that it will help ensure the more ordered growth and development of graduate studies in Ontario's universities. This report deals with all aspects of chemistry. Recommendations suggest: (1) the facilities for graduate work in chemistry in Ontario be sufficient to cater to the likely number of suitable Canadian students together with a component of foreign students; (2) the desirability of maintaining and improving the overall quality of Ph. D. study by concentrating it in a smaller number of programs should be seriously examined; (3) action be taken by the provincial government to facilitate the active involvement in research work of faculty members of departments not authorized to offer Ph. D. programs; (4) departments intensify efforts to share equipment, to introduce joint programs, to cross-appoint some faculty members, to build complementary areas of strength, and to avoid undesirable duplication; (5) the field of analytical chemistry be reinforced in some departments in Ontario universities; (6) universities ensure the existence of adequate criteria and procedures for determining which individual faculty members should act as supervisors of Ph.D. theses. Nine additional recommendations and the reports of the Council of Ontario Universities are included. (Author/MJM)

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Perspectives and Plans for Graduate Studies

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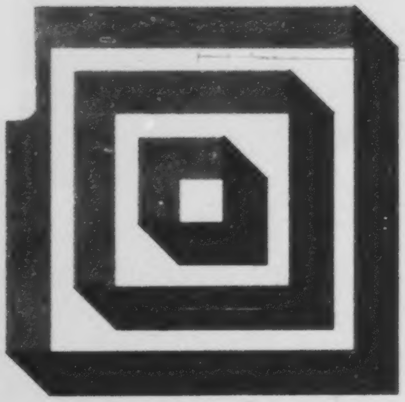

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Chemistry
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Advisory Committee on Academic Planning

Ontario Council on Graduate Studies

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Council of Ontario Universities
Conseil des Universités de l'Ontario

PERSPECTIVES AND PLANS FOR GRADUATE STUDIES

5. CHEMISTRY 1973*

Advisory Committee on Academic Planning
Ontario Council on Graduate Studies

74-5

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* The status of this report is given in Item 2 of the statement of principles, on page 1.

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FOREWORD

The Advisory Committee on Academic Planning (ACAP), as presently constituted, was established by the Ontario Council on Graduate Studies at the request of the Council of Ontario Universities in January, 1971. The Advisory Committee's terms of reference were directed broadly toward the effective planning and rationalization of long-term graduate development in Ontario's universities both at the level of individual disciplines and at a more general level. The Advisory Committee's activities are based on the premise that graduate work is the one area of university activity in which specialization among universities, cooperative arrangements and comprehensive planning are most necessary.

In March, 1971, concern over the rising costs for support of graduate work prompted the Ontario government to institute a general embargo on funding for any new graduate programme, that is, one which had no students enrolled on May 1, 1971. This embargo was subsequently modified to include only those disciplines in which over-expansion was felt to be potentially most serious. ACAP was to begin immediately planning studies in those disciplines which remained embargoed.

The disciplinary planning process begins with the formation of a discipline group composed of one representative from each university with an interest in graduate work in the planning area. The discipline group assists in defining the precise academic boundaries of each study, scrutinizes the data collection forms, prepares a list of potential consultants, maintains contact with the consultants during the study, and prepares a commentary on the consultants' report.

The final decision on consultants for the planning study is made by ACAP. The consultants are requested to make recommendations on programmes to be offered in Ontario, desirable and/or likely enrolments, the division of responsibility for programmes among universities, and the desirable extent of collaboration with related disciplines.

While the consultants' report is the single largest element in the final report on the planning study, ACAP considers the statement of each university's forward plans to be most significant. These forward plans are usually outlined prior to the planning study, and are used as a basis for comments from the universities concerned on the consultants' report.

On receipt of the consultants' report, and comments on it from the discipline group and the universities, ACAP begins work on its own recommendations for submission directly to the Council of Ontario Universities. COU considers the input from all sources, and prepares the position of the Ontario university community.

The following report is one of a series of disciplinary planning studies carried out by the Advisory Committee on Academic Planning and to be published by the Council of Ontario Universities. The emphasis of the report is on forward planning, and it is hoped that the implementation of COU's recommendations will help to ensure the more ordered growth and development of graduate studies in Ontario's universities.

* * * * *

Council of Ontario Universities
Conseil des Universités de l'Ontario

Report and Recommendations concerning Graduate Studies in Chemistry

On the instruction of the Council of Ontario Universities, the Advisory Committee on Academic Planning has conducted a planning assessment for chemistry. The resultant report from ACAP is attached together with the consultants' report, the comments by the discipline group, and the comments of the individual universities. The procedures followed and the planning techniques used are described in the ACAP report and are not repeated here. It is important for the reader to read the attachments in order to understand the recommendations in this Report from COU.

The Council received the ACAP report and supporting documentation on June 1, 1973. The content of the document was debated on that date, on July 19, 1973, and on September 7, 1973. As a result of these discussions this Report and Recommendations was prepared and approved by the Council on October 16, 1973. The Report is addressed to the Committee on University Affairs and the universities of Ontario.

The following principles have been adopted and will apply to this and all other COU Reports arising out of assessments.

1. Discipline assessments by ACAP should form the basis for planning by the universities of their development of graduate studies, particularly PhD programmes. On the basis of these assessments, COU should make its own recommendations on currently embargoed programmes. Each university must retain the freedom and responsibility to plan and implement its own academic development. However, the universities in embarking on a cooperative planning process have signalled their intentions of cooperating with the COU recommendations.

2. Universities generally plan their emphases in graduate study on the bases of related departments, not of single departments. Initially the sequential nature of the discipline planning assessments makes this difficult. However, by the summer of 1974 there will have been assessments of most of the social sciences, all of the physical sciences, engineering doctoral work, and a number of professional areas. On the information and recommendations then available, each university should be able to make decisions concerning its support of graduate programmes in these areas. Amendments to university responses to the individual discipline planning assessments may then be made in the wider context of a group of related disciplines and amendments to COU's original Reports on an individual discipline may be required.

3. The first concern in planning is to review the quality of graduate opportunities and of students in Ontario universities and to make judgements about how to proceed or not proceed based on quality considerations. The procedures have made use of highly qualified independent consultants who have no direct interest in the universities in Ontario. Accordingly, COU feels bound to accept their judgements about quality where they are stated clearly unless unconvinced that their conclusions about quality are consistent with their evidence. COU's recommendations in the case of programmes which are of unsatisfactory or questionable quality will call for discontinuation or the carrying out of an appraisal, if the continuation of the programme is not crucial to the province's offerings. In some cases, however, there may be a particular need for the programme and the appropriate recommendation will be to strengthen it, with an appraisal following that action. It is also possible that if there were found to be too large a number of broadly-based programmes there could be a recommendation to discontinue the weakest; in this case, an appraisal for a more limited programme might be relevant.

4. A second consideration is the scope of opportunities for graduate work in the discipline. Do the Ontario programmes together offer a satisfactory coverage of the main divisions of the discipline?

5. Numbers of students to be planned for will depend on the likely number of applicants of high quality and in some cases may relate to an estimate of society's needs. Such estimates may be reasonably reliable in some cases and not in others. If the plans of the universities appear to be consistent with the likely number of well-qualified applicants and there is either no satisfactory basis for estimating needs or there is no inconsistency between a reasonable estimate of need and the universities' plans, then COU will take note of the facts without making recommendations on the subject of numbers.

   If the numbers being planned for by the universities are grossly out of line with the anticipated total of well-qualified students, or a reliable estimate of needs, COU will make appropriate corrective recommendations. Depending on the circumstances, these may call for a change in the total numbers to be planned for and indications of which institutions should increase, decrease, or discontinue. The recommendations in serious cases may need to specify departmental figures for each university for a time. If the numbers being planned for are insufficient, the recommendations may call for expansion, or new programmes, and may have implications for both operating and capital costs.

   Unless there are exceptional circumstances, the recommendations concerning enrolment will not call for a university to refuse admission to any well-qualified student who wishes to work in a field in which that university offers a programme and in which it has the capacity to accommodate the student.

6. The quality of graduate programmes is partly dependent on size, and for each programme, depending on how it is designed and its scope, there is a minimum size of enrolment below which quality may suffer. That number cannot be expressed for the discipline as a whole but only for individual programmes depending on their purpose, their resources and their design.

7. Universities will be expected to notify COU if they intend to depart from the COU Report in any way which they believe might have a significant bearing on the provincial plans.

8. Appraisals arising as the result of assessments are to be based on the standards but not necessarily the scope of the acceptable programmes in the province.

General observations concerning chemistry

1. The quality of Ontario graduate programmes in chemistry is variable. Some are very good, and have gained international recognition. Others are not of the same calibre.
2. High quality may be better assured by reducing the number of broadly-based doctoral programmes than by distributing students among all the the existing departments.
3. Important opportunities exist for the universities to cooperate in order to make the best use of their resources.
4. The range of graduate programmes in chemistry embraces all the major divisions of chemistry and work of good quality exists in each of them. There is need to strengthen analytical chemistry in Ontario.
5. There is no satisfactory basis for forecasting manpower needs for chemists but there is evidence that both universities and students have responded to perceptions of the market prospects.
6. The universities collectively have the resources and have been planning for more graduate students than are justified on the basis of the likely number of applicants of high quality.
7. The three best existing general PhD programmes in chemistry could accommodate all the well-qualified applicants likely to be available in the next few years, but it would be consistent with reasonable provincial objectives to have in addition one or more small limited-enrolment specialized PhD programmes, or possibly even an additional general programme.

Recommendations

It is recommended that:

1. The facilities for graduate work in chemistry in Ontario be sufficient to cater to the likely number of suitable Canadian students together with a component of foreign students of high quality. The scale of graduate work in chemistry, as in any other discipline, should be reviewed regularly.
2. The desirability of maintaining and improving the overall quality of PhD study by concentrating it in a smaller number of programmes should be seriously examined.
3. Action be taken by the provincial government to facilitate the active involvement in research work of faculty members of departments not authorized to offer PhD programmes in the professors' fields of study. COU encourages universities and the Chemistry Discipline Group to take immediate action to ensure that these opportunities exist.

4. Departments, particularly those in close geographical proximity, intensify their present efforts to share equipment, to introduce joint programmes, to cross-appoint some faculty members, to build complementary areas of strength and to avoid undesirable duplication.

5. The field of analytical chemistry be reinforced in some departments in Ontario universities and that attention be paid to the useful application of this activity.

6. Universities ensure the existence of adequate criteria and procedures for determining which individual faculty members should act as supervisors of PhD theses.

7. Professors and departments advise students to take at least some of their graduate training at a university other than that where they obtain their bachelor's degree. The important point is felt to be that normally a student ought not to take all three degrees (BSc, MSc, PhD) at the same institution.

8. In all general scholarship schemes, the Government of Ontario, the National Research Council and the universities provide for a percentage of the awards to be open to able, well-qualified graduate students from abroad in competition with Canadian applicants.

9. The Chemistry Discipline Group, while performing the normal functions of a discipline group, continue in particular the present sharing of information on graduate admissions and on mechanisms for maintenance of standards, that it report regularly to ACAP on these matters and on cooperative actions and, that it give annual reports of the location of the undergraduate training of newly admitted graduate students.

10. Carleton, Guelph, Queen's, Waterloo, Windsor, and York either discontinue their doctoral programmes in chemistry or submit for appraisal a suitable proposal for doctoral work. In considering the proposed role for their departments, they should give full consideration to the possibilities of making arrangements with other universities for sharing graduate courses, cross-appointing professors and establishing joint programmes. Prior to or simultaneous with the submission of a proposal for appraisal, it should be transmitted to ACAP for an examination and possible advice concerning its effect on the overall provincial plan. None of the six universities should enrol any new doctoral students to begin their studies after the end of the fall term of 1974, until they have received a favourable appraisal of their proposed doctoral programmes. If the appraisal is unduly delayed for reasons beyond the control of the university, the date may be extended. The Appraisals Committee will be asked to instruct its consultants that the standards of quality (but not the range of specialties) to be met are those found in the approved PhD programmes in Ontario. OCGS will be asked to consider and make recommendations to COU on how these appraisals should differ from appraisals

carried out in the absence of an assessment. In considering the role of these six departments, the universities should bear in mind that the probable upper limit of available enrolment for all six is about 130 graduate students. Very few of these are likely to be doctoral candidates.

11 At least interim reports be made to ACAP by January, 1974, by each of the named universities on its action in connection with Recommendation 10.

12. McMaster, Ottawa, Toronto and Western continue their graduate programmes according to their expressed plans for the next two years and that during that period they report to ACAP the role that each department anticipates playing for the next five years in terms of field emphasis, enrolment and cooperative ventures with other chemistry departments.

13. No doctoral programmes additional to those resulting from Recommendations 10 and 12 should be contemplated in the foreseeable future. This recommendation should be reviewed in 1978.

14. ACAP make a further report to COU on the provincial plan for graduate study in chemistry on the completion of the action called for in Recommendations 10 and 12 and in any case not later than May of 1975.

15. In view of the acceptance of these recommendations by COU and the completion of the chemistry assessment, CUA request the Minister to remove the embargo on chemistry in accordance with the original announcement of the Minister that new graduate programmes would be embargoed until, for each discipline, a planning study has been conducted.

Notes concerning the recommendations

Re: Recommendation 2

This recommendation is addressed to the six universities listed in Recommendation 10 which are asked to discontinue work or seek appraisal.

Re: Recommendation 3

This recommendation suggests the need for recognition within the operating grants formula of the costs for research support now covered mainly through graduate student entitlements.

Re: Recommendation 10

The listed programmes were judged by the consultants to be the weaker programmes in chemistry. In the case of York there is ambiguity in the consultants' report shown by the use of such expressions as "the programme of this department appears to be in trouble", and the York department is "marginal". Consequently, COU does not accept the ACAP recommendation that this programme be grouped with the acceptable programmes without an appraisal.

Re: Recommendation 12

The enrolment plans for McMaster, Ottawa, Toronto and Western for the next two years are to maintain or slightly increase their current enrolments.

	# of graduate students 1972-73
McMaster	83
Ottawa	30
Toronto	77
Western	57

Re: Recommendation 15

Lifting of the embargo in this case is a formality recognizing the existence of a plan for chemistry. The plan, however, provides for no new programmes and the discontinuance of some existing programmes.

October 16, 1973

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ADVISORY COMMITTEE ON ACADEMIC PLANNING

ONTARIO COUNCIL ON GRADUATE STUDIES

REPORT TO THE COUNCIL OF ONTARIO UNIVERSITIES

ON

CHEMISTRY PLANNING ASSESSMENT

August 28, 1973

PROCEDURE

On the advice of the Ontario Council on Graduate Studies, the Council of Ontario Universities on September 17, 1971, instructed the Advisory Committee on Academic Planning to conduct a formal planning assessment for chemistry.

A Discipline Group was formed consisting of a member named by each interested university. A list of members is attached as Appendix E. Professor L.A.K. Watt held the ACAP chemistry portfolio and attended meetings when ACAP representation was necessary.

The procedure and terms of reference for the planning assessment is attached as Appendix D.

The Discipline Group began its meetings in October 1971. In accordance with the procedure, the Discipline Group provided ACAP with a list of possible consultants. ACAP obtained the services of Professor F. Basolo, Northwestern University, Professor R. U. Lemieux, University of Alberta, Professor W. A. Noyes, University of Texas, and Professor G. M. Volkoff, University of British Columbia. Brief curricula vitarum appear as Appendix G. Professor Volkoff played the role of the senior Canadian academic from outside the discipline in this planning assessment. The consultants held their first meeting in Toronto in May 1972, and discussed with the Discipline Group their schedule of visits to the universities. These took place during July, August and October.

The draft report of recommendations was presented to the Discipline Group for informal comments on February 17, 1973, and the final report was subsequently received and distributed March 23, 1973. The Discipline Group and the universities were requested to submit comments to ACAP by April 26. The Discipline Group was also given the opportunity to add to its comments after it had seen the comments of the universities.

After receipt of these comments, a subcommittee of four ACAP members met to draft the ACAP recommendations to COU. This subcommittee felt that no interviews with university representatives would be necessary since, in this case, no obscure points were raised. The subcommittee did, however, write to the consultants for interpretation of several points. The Discipline Group comments plus those of the universities appear in Appendices B and C respectively. The latter includes only those comments specified by each university for publication.

This report then is based on these data, reports and comments, and sets out recommendations for COU on the plan for graduate work in chemistry in the province for the next two or three years. A further report will be necessary in 1975 in view of action recommended here.

As is required, this report is made directly to COU. It has been transmitted, as well, to the Ontario Council on Graduate Studies and the Council of Deans of Arts and Science for information.

RECOMMENDATIONS

It is emphasized that the consultants' report contains a great deal of valuable advice. It is an essential and integral part of this report to COU. In the ACAP report itself we have dealt usually only with aspects of the consultants' report which seem to need comment, either because they are controversial, particularly significant, or in need of amplification.

The following are ACAP's recommendations adoption of which would constitute final formal action on this planning assessment.

C1

It is recommended that the facilities for graduate work in chemistry in Ontario be sufficient to cater to the likely number of suitable Canadian students together with a component of foreign students of high quality. The scale of graduate work in chemistry, as in any other discipline, should be reviewed regularly. (This recommendation is intended to replace most of Recommendations 1 and 2 in the consultants' report). (pages A-1 to A-8, A-26 to A-31, A-50 to A-51, B-1, B-5)

C2

The desirability of maintaining and improving the overall quality of Ph.D. study by concentrating it in a smaller number of programmes should be seriously examined. (Consultants' Recommendation 2, pages A-4, A-5 to A-8, A-28 to A-29, A-32)

C3

It is recommended that action be taken by the provincial government to facilitate the active involvement in research work of faculty members of departments not authorized to offer PhD programmes in the professors' fields of study. (Consultants' Recommendation 5, pages A-11, A-12, A-19)

C4

It is recommended that departments, particularly those in close geographical proximity, intensify their present efforts to share equipment, to introduce joint programmes, to cross-appoint some faculty members, to build complementary areas of strength and to avoid undesirable duplication. (Consultants' Recommendation 6, pages A-49 to A-50)

C5

It is recommended that the field of analytical chemistry be reinforced in some departments in Ontario universities and that attention be paid to the useful application of this activity. (Consultants' Recommendation 7a, pages A-41, A-58)

C6

ACAP has no comment on Recommendation 7b in the consultants' report. We note that the forward planning of biochemistry was not a part of this planning study.

RECOMMENDATIONS

C7

On the consultants' Recommendation 8, we have no comment.

C8

It is recommended to universities that they give careful consideration to the consultants' Recommendation 9 which supports high standards for tenure. (pages A-9 to A-11, A-46 to A-49)

C9

It is recommended that universities ensure the existence of adequate criteria and procedures for determining which individual faculty members should act as supervisors of PhD theses. (Consultants' Recommendation 10, page A-60)

C10

It is recommended that professors and departments advise students to take at least some of their graduate training at a university other than that where they obtain their bachelor's degree. The important point is felt to be that normally a student ought not to take all three degrees (B.Sc., M.Sc., PhD) at the same institution. (Consultants' Recommendation 11, page A-52)

C11

It is recommended to the Government of Ontario, the National Research Council and the universities that all general scholarship schemes provide for a percentage of the awards to be open to able, well-qualified graduate students from abroad in competition with Canadian applicants. (Consultants' Recommendation 12, page A-53)

C12

It is recommended that the Chemistry Discipline Group, while performing the normal functions of a discipline group as described in the general introduction and in Appendix F, continue in particular the present sharing of information on graduate admissions and on mechanisms for maintenance of standards, that it report regularly to ACAP on these matters and on co-operative actions of the kind urged in Recommendation C4, and, in connection with Recommendation C10, that it give annual reports of the location of the undergraduate training of newly admitted graduate students. (Consultants' Recommendation 13, page A-53)

C13

It is recommended that Carleton, Guelph, Queen's, Waterloo and Windsor either discontinue their doctoral programmes in chemistry or submit for appraisal a suitable proposal for doctoral work. In considering the proposed role for their departments, they should give full consideration to

RECOMMENDATIONS

C13 (contd)

the possibilities of making arrangements with other universities for sharing graduate courses, cross-appointing professors and establishing joint programmes. Prior to or simultaneous with the submission of a proposal for appraisal, it should be transmitted to ACAP for an examination and possible advice concerning its effect on the overall provincial plan. None of the five universities should enrol any new doctoral students after the fall term of 1974, until they have received a favourable appraisal of their proposed doctoral programmes. The Appraisals Committee should be asked to instruct its consultants that the standards to be met are those found in the approved Ph.D. programmes in Ontario and that they should take account of the criteria we have enunciated on pages 18 and 19 and our remark there about programmes with small enrolment. In considering the role of these five departments, the universities should bear in mind that the probable upper limit of available enrolment for all five is 100 graduate students, and that the number of master's students currently enrolled outside the five stronger departments is 83; this leaves very few doctoral candidates.

C14

It is recommended that McMaster, Ottawa, Toronto, Western and York plan for full-time enrolment for the next two years as indicated in the text, i.e. about the current enrolment or slightly more at the first four and an increase to about 30 at York, and that they be requested to report to ACAP the role that each department anticipates playing for the next five years, in terms of field emphasis, enrolment, and co-operative ventures with other chemistry departments.

C15

It is recommended that at least interim reports be made to ACAP by January, 1974, by each of the named universites on its action in connection with Recommendations C13 and C14.

C16

No doctoral programmes additional to those resulting from Recommendations C13 and C14 should be contemplated in the foreseeable future. This recommendation should be reviewed in 1978.

C17

It is recommended that ACAP make a further report to COU on the provincial plan for graduate study in chemistry on the completion of the action called for in Recommendations C13 and C14 and in any case not later than May of 1975.

RECOMMENDATIONS

C18

It is recommended that COU adopt the recommendations of this report, inform CUA that it has done so and request that the embargo on chemistry be now removed, in accordance with the original announcement of the Minister that new graduate programmes would be embargoed until, for each discipline, a planning study has been conducted.

GENERAL INTRODUCTION

Planning Techniques

For some years now, the universities of Ontario have been committed to the belief that the quality and effectiveness of graduate study in the province can be ensured only by collective and cooperative action. This implies a mechanism for continuing consultation and agreement so that the plans of each university for each of its disciplines are concerted with those of the other universities. At any given time there will exist a plan for the development of each discipline, with agreed and understood roles for each department; since graduate education is the most advanced formal intellectual activity and is, therefore, undergoing change, it is necessary that such plans be kept under regular review and be subject to ready amendment.

The Council of Ontario Universities has assigned to the Ontario Council on Graduate Studies the task of advising it on the development of such plans and of the steps to be taken to carry them into effect. The Standing Committee which carries out these tasks for OCGS is the Advisory Committee on Academic Planning. A significant role is also played by the discipline groups, one of which is established for each subject, with a representative from each interested university. Each discipline group has the function of assisting and advising ACAP in connection with its own subject.

The above may give the impression that the planning activity is fragmented on a disciplinary basis. This would, of course, not be acceptable. Since the development of one department in a university should not be considered independently of its contribution to the rest of its university and of the influence of the university as a whole on the department, it is most important that universities as institutions play a central role in the planning process. One of the most effective ways of doing this is by indicating to ACAP the nature of institutional commitments to a department and institutional aspirations for the department.

The most significant single input to a planning assessment is the set of statements from each university of its plans for its department. When these are subjected to collective scrutiny it may be found that their totality constitutes a reasonable plan for the discipline in Ontario, but in any case this set of plans is the first approximation to the provincial plan, which the planning assessment may have to refine if there are duplicated features, lacunae in offerings, too large a total enrolment, or other reasons to recommend altering some of the university plans. The universities are also involved in that the bodies that act on ACAP reports, i.e. both COU and OCGS, are composed of universities.

The formal documents stating the responsibilities of ACAP and the Discipline Groups are Appendix F. Briefly summarized, it is ACAP's function to advise on steps to be taken to implement effective provincial planning at the graduate level, to promote the arranging of the graduate programmes of the province in order to enhance and sustain quality and to avoid undesirable duplication, and, when necessary, to carry out formal planning reviews for disciplines. A discipline group has the responsibility of keeping under review the plans for graduate work in the discipline and making regular progress reports to ACAP in connection with graduate work in that subject. To make all this possible, it has been agreed that ACAP may communicate directly with universities and discipline groups, to request necessary information, to discuss reports, to convene meetings, and to make and receive proposals for the future.

The above information has been given in some detail because it constitutes the mechanism currently approved by COU for cooperative graduate work. It is fair to say that in 1971 there was no mutually agreed plan for graduate study in any discipline. Our task is not only to generate the first such plan for each subject but also to ensure that it is kept under continual review.

There are four fundamental components in the plan. The first is analysis of the fields of study, the formats of study which should be available to prospective students in the province. The second is an estimate of overall provincial enrolment at master's and doctoral levels based principally on the likely numbers of highly qualified applicants. In regard to considerations of manpower needs for the province of Ontario, ACAP is conscious of the unreliability of forecasts and, except in special cases, subscribes to the approach proposed in the Macdonald Report (1969):

> "The country as a whole and the provinces must be concerned about manpower requirements. This concern can be expressed in the first instance through careful survey and forecasting of manpower needs on a continuing basis. Such forecasts should be given wide circulation. It is reasonable to expect that universities will respond by creating additional opportunities for study in the areas of shortage. In addition, the universities through their counselling services have a duty to advise students about the opportunities in various fields from the standpoint not only of intellectual challenge but also of vocational prospects and social utility. The reaction of prospective students to such forecasts is likely to provide an effective control. We believe the market-place, if its trends are made explicit, offers an adequate governor to prevent serious surfeit and to encourage movement of students toward fields of opportunity."

The third component of the plan is an indication of the role to be played by each department in terms of the programme it will offer and its academic emphasis. Cooperative arrangements between departments are stressed. The fourth component consists of an examination of the enrolment plans of the universities and consideration as to whether the universities' plans and the predicted enrolment for this discipline are consistent. If not, some appropriate action should be recommended to COU. It will be seen that although there may also be other aspects, these are four necessary components in such a plan.

In the chemistry assessment, an imbalance appeared, with the universities planning for more doctoral students than the expected number of highly qualified students, and accordingly recommendations to correct this imbalance have been made.

One must hasten to add that the future is uncertain and that to forecast intellectual trends, student interests, and employment markets five years hence is to undertake to examine many variables. Of course, this is not a new exercise since all universities have had to make decisions about building, staff hiring, library expansion, equipment investment and so forth and have done so on a basis of similar forecasts. Perhaps sometimes the forecasts have been more intuitive than consciously recognized, but they have certainly been there. All that is new is to make such plans systematically for the province.

It will be realized that, at a minimum, the ongoing planning procedures we have indicated requires annual reporting of enrolments and annual examination of admission standards. When there are indications from these or other sources that some aspects of the plan for the discipline are not being realized, it will be necessary for ACAP to initiate a review. Such a review would usually not involve outside consultants. Whether the impetus came from a discipline group, a university or ACAP itself, comments would be sought from all concerned and the review would culminate in a report to COU recommending an amendment to the plan.

If a university notifies ACAP of its intention to depart from its accepted role (for example to enrol numbers substantially at variance with its understood plan), ACAP will review the situation in the light of any other such notifications it may have received and any other pertinent factors. The extent of any further study would depend on the situation, but if ACAP felt that the university's new plan could be a cause for concern, its first step would be to seek full discussion with the university. Normally there would already have been discussion in the discipline group and between universities and the university would have reached its intention after a careful examination of the general situation of graduate study in the discipline. Thus the ACAP decision would be straightforward and a change in plan would be recommended to COU through OCGS. If, however, ACAP still felt that there was a probability that the university's action might be found, on further study, to be potentially harmful to the system, it would probably next seek comment from other universities concerned and from the discipline group. In any case, ACAP would eventually make some recommendation to COU (through OCGS) concerning the variation.

It is difficult without a concrete case to speculate on likely recommendations, but perhaps two hypothetical situations will illustrate the extremes. If a university indicated that, without any marked change in the academic emphasis of its department, it proposed to arrange to enrol somewhere around 70 graduate students instead of about 50, and if there were no changes at other universities and no potential developments which could be substantially affected, ACAP would presumably simply notify COU of the university's intention and recommend that it be recognized as an alteration in plan for the discipline. At the other extreme if a university proposed to begin a new programme designed to enrol fairly soon some 30 Ph.D. students in a field of the discipline already well covered in other universities, it would clearly be necessary to obtain reaction from the discipline group and from other universities and perhaps even some expert advice, in order for ACAP to generate an advisory position concerning the impact of the proposal on the system and suggestions to the university concerned and to COU. As has been noted, if there had been advance inter-university discussions and agreement, this would be a positive factor in ACAP's assessment, but there is of course the possibility that the recommendation would call for modification of the university's intention; we take that to be the obvious consequence of system planning. Of course, the university could decide to act in a manner contrary to a COU recommendation, accepting whatever consequences would result; we take that to be the basic right of university autonomy.

Enrolment Analysis

We noted in the preceding pages that there are four components in a provincial plan for a discipline. Each of these four components corresponds to a section in the terms of reference of the consultants in a planning assessment. The chemistry consultants chose not to make any numerical recommendations about enrolment on the grounds that "their crystal ball... is not any less clouded than that of local authorities." Instead they expressed their hope that all those concerned "will not over-react to a seeming temporary mismatch between the number of students currently seeking and obtaining Ph.D. degrees in chemistry and the openings available to them." An over-reaction may already be in evidence or it may not, but in any case there has been a substantial drop in the chemistry enrolment at the graduate level in the last few years. The consultants have given certain other general advice about enrolment which has been helpful in the analysis which ACAP has made in this report. The consultants have carefully considered the strengths and weaknesses of the various departments and, as one of them pointed out in reply to ACAP's request for clarification, their report gives pretty clear guidelines as to how to proceed with a plan once one has formed a view about overall chemistry enrolment in Ontario.

It will appear in the following that ACAP has taken advantage of these inherent guidelines. We shall organize our report in the form of recommendations based on each of those in the consultants' report plus a further section discussing enrolment and proposing certain action.

In brief, we find that for chemistry there is an enrolment problem, since the sum-total of separate university plans exceeds the likely number of students, even without any reductions due to student perception of an unfavourable employment market. Moreover, there is a minimum number of students necessary in a broad-ranging programme in order to operate it at high standards of academic quality, and this number imposes restrictions. We believe that the best way to find a solution to this problem is to invite certain of the departments either to cease doctoral work or to design carefully constructed specialized doctoral programmes with small and limited enrolment and, wherever appropriate, in conjunction with the departments in another university. A fuller discussion follows later in the report, as do precise recommendations for action.

. Cost Analysis

Before embarking on this, it seems desirable to comment on Section 4 of the consultants' report which considers the cost of graduate work in chemistry. ACAP consultants are not requested to undertake such studies, not because they are unimportant but because the problem of separating costs for undergraduate teaching, for research, and for graduate work is an extremely subtle one and the results depend on some basic assumptions including, for example, a judgment of the amount of time a professor should spend in research even if his other responsibility consists only of undergraduate instruction. We recognize that graduate work is expensive and that we must in the province make the most effective use of our human and financial resources, but we believe that one can find the most effective solutions without entering the quagmires of cost accounting. In the wake of the report of the Commission on Post-Secondary Education in Ontario, the techniques for providing operating funds for universities are again under study. The best techniques are presumably those which do not steer academic decisions in the direction of financial advantage and for this reason studies of costs of graduate work are significant. ACAP believes that its planning should be done without primary reference to the method of funding so that such steering effects are minimized. We do not, therefore, intend to comment on the consultants' Section 4, although some of the universities have done so. We draw attention in particular to the University of Toronto's discussion (page C-34) concerning economies of scale.

There is, however, one point that should perhaps be made. In Ontario, full-time students are permitted to work as teaching assistants for a maximum of ten hours per week. Since this includes preparation and marking, it normally implies a maximum of two laboratory sections per week, usually not more than 25 or 30 weeks' work involved in a year. The rate of pay works out to be roughly equivalent to that of high school teachers and it is therefore reasonable to suppose that when a department has too few graduate students to do all the necessary demonstrating it can employ suitable full-time and part-time personnel without significant extra cost.

In order to avoid any cause for misunderstanding on this score, in view of the consultants' position that academic factors require a minimum enrolment in a PhD department, we requested the consultants to react to the following question: "If enrolment should drop to about 400, should we take the necessary steps to maintain the leading departments near their present size or should we distribute the students to make all departments academically viable?" None of the consultants abandoned their position that there is a minimum critical size for acceptable doctoral work. One said that the least desirable arrangement would be to have 40 graduate students in each of ten departments and indicated that this kind of "democracy" should not apply to education as scholarly endeavour. Another estimated that five or six PhD departments in the province would perhaps be reasonable. A third suggested that an eventual enrolment of over 30 in each of the ten departments is so highly improbable as not to be worth consideration but that if it happended it would mean that the better departments had ceased to be better.

In short, none of the consultants is sympathetic to what may be seen as an inevitable mediocrity that would result from a roughly even distribution of enrolments. Three of them do, however, caution against precipitate action. ACAP has taken this recommendation seriously in view of its analysis of likely enrolments and makes certain proposals below in Recommendation C13.

Recommendation C3

> It is recommended that action be taken by the provincial government to facilitate the active involvement in research work of faculty members of departments not authorized to offer PhD programmes in the professors' fields of study. (Consultants' Recommendation 5, pages A-11, A-12, A-19)

We wish to reiterate the view that research is an essential activity of most university professors and that without it their teaching will become increasingly less satisfactory. Further, as has been repeatedly pointed out, research does not necessarily imply the involvement of graduate students. Unfortunately, at present a large fraction of the provincial support for research is generated by the weight allotted to doctoral students in the operating income formula. Since there clearly will not be enough graduate students to go around, there certainly will be professors who will be doing research without students. Their research usually requires scientific and technical assistants, i.e. post-doctoral fellows and technicians. Mechanisms that would generate operating income for research but independent of graduate student enrolment should be devised. One such device is giving a weight to post-doctoral fellows. We urge that this be seriously examined by COU and CUA. These considerations apply not only to chemistry but to most other disciplines.

Recommendation C4

> It is recommended that departments, particularly those in close geographical proximity, intensify their present efforts to share equipment, to introduce joint programmes, to cross-appoint some faculty members, to build complementary areas of strength and to avoid undesirable duplication. (Consultants' Recommendation 6, pages A-49 to A-50)

It is a fundamental tenet of good planning for the province that departments should not be inward-looking but should endeavour to work together in the way suggested. There is further discussion of this following Recommendations C13 and C14.

Recommendation C5

> It is recommended that the field of analytical chemistry be reinforced in some departments in Ontario universities and that attention be paid to the useful application of this activity. (Consultants' Recommendation 7a, pages A-41, A-58)

The Discipline Group and the University of Waterloo, in their comments on the consultants' report, particularly take up this recommendation, which appears to be of importance for a number of currently active fields of application. The consultants lay considerable stress on the applications in pollution and ecological problems which are of current public concern, but obviously analytical chemists should also work in other areas.

Recommendation C6

> ACAP has no comment on Recommendation 7b in the consultants' report. We note that the forward planning of biochemistry was not a part of this planning study.

Recommendation C7

> On the consultants' Recommendation 8, we have no comment.

Recommendation C8

> It is recommended to universities that they give careful consideration to the consultants' Recommendation 9 which supports high standards for tenure.(pages A-9 to A-11, A-46 to A-49).

Recommendation C9

> It is recommended that universities ensure the existence of adequate criteria and procedures for determining which individual faculty members should act as supervisors of PhD theses. (Consultants' Recommendation 10, page A-60)

Recommendation C10

> It is recommended that professors and departments advise students to take at least some of their graduate training at a university other than that where they obtain their bachelor's degree. The important point is felt to be that normally a student ought not to take all three degrees (B.Sc., M.Sc., PhD) at the same institution. (Consultants' Recommendation 11, page A-52)

In response to some statements, we must indicate our scepticism that having a student work with a different supervisor is in any way equivalent to the broadening experience of changing departments. We feel that these comments apply even to the largest departments. We express our hope that chemistry departments outside Ontario will also follow this advice. There may be circumstances in which it is reasonable that a student take an M.Sc. at his undergraduate university, and there are always a few other cases where the student's circumstances are such as to make it not too unreasonable for him to remain at his undergraduate university for all three degrees. We ask that the Discipline Group make annual reports on the implementation of this Recommendation.

Recommendation C11

> It is recommended to the Government of Ontario, the National Research Council and the universities that all general scholarship schemes provide for a percentage of the awards to be open to able, well-qualified graduate students from abroad in competition with Canadian applicants. (Consultants' Recommendation 12, page A-53)

We agree strongly with the consultants that a graduate student body should be cosmopolitan and that our most active departments and professors should supervise promising students from other countries. We believe that the best way of ensuring that high standards are maintained is to arrange that stipends for foreign students be obtained in scholarship competitions, and indeed in those same competitions which select the most able Canadians. This principle is incorporated in the recommendations which COU and CUA have already made for the new Ontario Graduate Scholarship programme. It is urged that is also be incorporated in the National Research Council award scheme.

Recommendation C12

> It is recommended that the Chemistry Discipline Group, while performing the normal functions of a discipline group as described in the general introduction and in Appendix F, continue in particular the present sharing of information on graduate admissions and on mechanisms for maintenance of standards, that it report regularly to ACAP on these matters and on co-operative actions of the kind urged in Recommendation C4, and, in connection with Recommendation C10, that it give annual reports of the location of the undergraduate training of newly admitted graduate students. (Consultants' Recommendation 13, page A-53)

ACAP would like to associate itself with the consultants in their commendation of the work already done by the Committee of Chemistry Chairmen. The Discipline Group will continue to play an important role in monitoring graduate work in chemistry and in advising on its future.

CRITERIA FOR DOCTORAL PROGRAMMES AND ENROLMENT RECOMMENDATIONS

A very substantial part of the consultants' report is devoted to a discussion of the necessary conditions which must be met in order that a department be able to offer doctoral work of good quality. We do not propose to repeat these arguments which are clearly set forth by the consultants, in particular on pages A-4, A-7, A-8, A-10, A-11, A-32 and in their Recommendation 3 on page A-56. ACAP accepts these views in principle and in most of their details, but some points which have been raised by the university and Discipline Group comments suggest the need for some modification or elucidation of specific aspects.

Some pleas have been entered that students can receive good training in programmes of low enrolment. In general we do not accept this view, since one of the most significant aspects of the maturing process of the young scholar is the searching question, and the tentative answer the thrust and parry of informal scientific conversation with his peers. In any situation where two or three major branches of chemistry are being pursued, this must imply a substantial enrolment, at least the 30 suggested by the consultants. It is sometimes said that staff-student contact is better when the enrolment is small. Since a doctoral student interacts mostly with one staff member, his supervisor, and since teaching loads are not noticeably different in smaller departments and since the number of graduate students per supervisor does not vary greatly from department to department in any one field of chemistry, it is a little hard to see why the individual student would get any more of the time of the individual professor in a smaller programme--and he would miss the interaction with his peers.

On the other hand, we do think that post-doctoral fellows can play the same role as other students in providing the informal learning of a peer group. We use the term post-doctoral fellow in the standard National Research Council sense, i.e. a chemist at most two or three years from his Ph.D. degree engaging essentially in research and with quite limited, if any, teaching responsibility. ACAP believes that post-doctoral fellows should be given some weight in deciding whether or not an enrolment is of viable size for a good academic programme.

We wish to make some comments with respect to certain paragraphs of the consultants' Recommendation 3. Their paragraph a specifies the necessary staff provision in each of three fields. We note that in view of the above arguments there clearly should also be a viable student group in at least the two strongest branches. We specify this as at least 15 graduate students and post-doctoral fellows in each of these branches. We expect to find master's students in other branches in possibly smaller numbers.

The consultants' paragraph b calls for "sufficient eminence of faculty to attract able graduate students." We believe that great eminence does not always attract graduate students since it is known that some eminent scientists are not particularly good student supervisors and since in any case students realize that selecting a department is not the same thing as obtaining the assurance that he can work with a given professor. In any case, we believe that this condition is covered by the prescriptions of faculty strength and of enrolment sizes (paragraph a and also by Recommendation C9.)

Paragraph e deals with the size of the undergraduate base. We do not see in what way this is academically relevant and, as we have already noted, questions of financial viability are not central to this study.

On page A-32 the consultants indicate that a Ph.D. production of 10 per year is considered acceptable, although barely so. This of course is inconsistent with a total enrolment of 30 graduate students. Indeed, it implies an enrolment of about 35 Ph.D. students and at least 15 M.Sc. students, for a total departmental enrolment of about 50. The consultants indicate on page A-8 that their minimum viable department of 30 is expected to grow further.

We therefore adopt as normal criteria for a Ph.D. programme in chemistry:

(1) a minimum staff of 15 full-time faculty members of the rank of assistant professor or above with provision for growth if the staff is only 15. (pages A-7 and A-32);

(2) "strength" in at least one of three traditional branches of chemistry (inorganic, organic and physical), "strength" in a second branch selected from an augmented list containing analytical, biochemical and theoretical branches in addition to the traditional three, and "competence" in at least one more branch from this augmented list. (Note that the strength for a programme need not lie in one department. For example professors in a department of biochemistry could be involved. It is, however, important in such a case that one really be dealing with a single programme in which there are the formal and informal contacts and controls typical within a department.);

(3) a graduate student enrolment somewhat in excess of 30;

(4) a minimum component of at least 15 students and post-doctoral fellows in each of at least two of the branches with "strength" referred to in (2);

(5) related departments (e.g. mathematics, physics, biology) should be competent to provide the necessary auxiliary training. (This does not imply that they need offer the doctorate.);

(6) the presence of several post-doctoral fellows is highly desirable.

Despite the above general position, we realize that there may be special circumstances in which a small programme could provide a good doctoral training and if a university wished to support a department in such a venture and if the careful examination inherent in an appraisal showed that special conditions did exist, we would not want the general rule to be considered to prohibit the programme. We emphasize that this would be a special case, subject to appraisal of a quite specific proposal.

We now turn to an examination of enrolment prospects. Table 1 shows the full-time enrolment in the chemistry departments for the last six years. Table 2 shows the number of master's students for each year, indicating whether they have Canadian or non-Canadian bachelor's degrees. It will be observed (Table 1) that after a relatively steady period the total enrolment has dropped markedly in the last two years and is now 448. One can anticipate a further drop for 1973-74 since those obtaining Ph.D.'s this spring will come from the years of larger intake about four years ago and are unlikely to be balanced in number by beginning students.

What can be said about the future? On page A-28 the consultants tell us that "the future of Ph.D. programmes in Ontario as elsewhere in Canada will rest more on the available number of suitable Canadian students than all other relevant factors combined." There is a limit on the number of interested students with the necessary ability. There have been some suggestions that this limit was exceeded in the easy employment days of the 1960's, but we find this hard to document. In any case, the tighter current market will likely mean that only students with considerable confidence in their ability will make the investment in doctoral work. Let us see what the number of students may be, even without an attempt to evaluate future manpower demand.

In 1971-72 Ontario gave relevant bachelor's degrees to about 180 students (four-year degrees with some specialization in chemistry). Probably fewer than half would enter graduate school in chemistry. Assuming an approximate inter-provincial balance, one might expect fewer than 90 entrants to graduate chemistry departments in Ontario from all the Canadian universities. (This is consistent with the figures in Table 2 since they include some full-time master's students in the second year of graduate study.) Allowing for wastage and the fact that not all intend to proceed to the doctorate, this would imply in a steady-state situation an enrolment of about 300 from this source. (This is also seen to be consistent with the master's/doctor's ratio given by the figures of Table 1.) Since undergraduate enrolment in the sciences has been pretty static for the last three or four years, there can be no increase in Canadian bachelor's degrees in chemistry for some time.

The number of non-Canadian graduate students in chemistry has been appreciable but, as Table 2 shows, there has been a marked effect in the last two years of policy changes in scholarship and assistantship rules and immigration regulations. In fact, there is a danger that the number of foreign students will become much too low. We have already stressed the importance of a foreign student component and we believe that about 20% is a healthy number.

The result of this approach is to predict an enrolment of about 360 full-time chemistry students. If there were a resurgence of interest amongst Canadian undergraduates, it might reach 400. We see this as the likely enrolment for about the next five years; and indicate our "best judgement" that at each point in the above argument we have chosen "optimistic" alternatives.

This conclusion has profound significance for the doctoral programmes of the province. The consultants' report makes clear that the ten departments concerned vary markedly in their standing. Three are clearly outstanding and, of these, two cover a broad spectrum of modern chemistry. Two other departments of smaller enrolment are described as of high quality and competent to give the Ph.D., although one of these is described as marginal at one point in the report. The other five departments are described as substandard from the point of view of offering the doctorate. These in turn fall into two groups, with two of them (Queen's and Waterloo) being noticeably closer to satisfying the criteria than are the other three.

We emphasize that in accepting this view of the departments, we are basing our opinions on a careful reading of the whole of the consultants' report, not just on Table VIII. Also since there appeared to be some difference in the position of the Queen's department as portrayed in the Table from that described at several places in the text, we asked the consultants for clarification on this specific point. Their replies indicated their view that Queen's is one of the stronger of the five weaker departments whose competence to give the Ph.D. is in question.

The five stronger departments are capable of handling the complete enrolment which we have forecast. In 1969-70 they had 419 full-time students and were not over-strained. Moreover, the consultants have indicated that the preservation of high quality requires that these departments maintain academically viable numbers of students. It would be nice to feel that the free choice of students would automatically populate the better departments but in fact if one compares 1969-70 with 1972-73, we find that the Ph.D. enrolment in the five stronger departments dropped by 25% (from 285 to 214) while in the five weaker departments it changed hardly at all (from 111 to 105). There are a number of explanations possible, but we have insufficient evidence to comment further. In any case, one is led to expect substantial enrolments in the stronger departments, whether because one thinks this is the most effective way of using our resources for the education of students or because one thinks it is the natural consequence of student choice. Noting that the five stronger universities could absorb the complete anticipated enrolment, we now ask what is the smallest number which a plan should show of them. We would put this at 300[1]. This implies that there would be only about 100 graduate students at most distributed amongst the other universities. Since a department offering an adequate Ph.D. programme should have an enrolment of at least 30 graduate students, it is evident that Ontario ought not to continue to support ten doctoral programmes in chemistry.

As we have indicated, the consultants agree with this position. They suggest, however, that departments be given five years in which to react and, at the end of this time under-populated programmes would be discontinued. We do not find this a satisfactory proposal, either from the point of view of the student, of the faculty member, or of the concept of a provincial system of co-operative planning. At the same time, we are very aware of the dangers of precipitate action in the situation.

In this case, where doubt has been cast on the standing of a large number of departments, it would be unwise to recommend the phasing out of any department on the basis of relative quality without a more specific study. We believe that these universities should have the option of deciding to discontinue their programmes or of proposing to continue, probably with a redesigned and limited programme appropriate to their institutional goals and to the provincial system as a whole. If they propose to continue they should seek appraisal for their proposal.

We point out that, from the point of view of planning, the standard of the appraisal now becomes important. In the past, the Appraisals Committee has used what might be called generally accepted standards for the offering of a degree. It is quite possible that all our chemistry departments meet this rather loosely defined standard. What is important is that those who offer the Ph.D. in chemistry meet a more-than-minimal standard of excellence. If there is one principal theme in the consultants' report, it is that. We, therefore, recommend that in any chemistry appraisal it will be necessary to use a somewhat different set of criteria, related to this report and to the standards typified by the five stronger departments in Ontario.

The question arises as to what admission policy should be in the interim before appraisals can be conducted. Admissions for the fall of 1973 are presumably already complete and we see no need to interfere with them, but it is clear that after that admission should be restricted until such time as the university obtains a favourable appraisal.

As we noted above, there do appear to be gradations in the strengths of the five departments in question and there certainly are differences in the size of their current doctoral enrolments.

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[1] This is based on current enrolments, plus necessary growth at York.

Bearing in mind the above factors, ACAP has framed the following recommendation.

Recommendation C13

> It is recommended that Carleton, Guelph, Queen's, Waterloo and Windsor either discontinue their doctoral programmes in chemistry or submit for appraisal a suitable proposal for doctoral work. In considering the proposed role for their departments, they should give full consideration to the possibilities of making arrangements with other universities for sharing graduate courses, cross-appointing professors and establishing joint programmes. Prior to or simultaneous with the submission of a proposal for appraisal, it should be transmitted to ACAP for an examination and possible advice concerning its effect on the overall provincial plan. None of the five universities should enrol any new doctoral students after the fall term of 1974, until they have received a favourable appraisal of their proposed doctoral programmes. The Appraisals Committee should be asked to instruct its consultants that the standards to be met are those found in the approved Ph.D. programmes in Ontario and that they should take account of the criteria we have enunciated on pages 18-19 and our remark there about programmes with small enrolment. In considering the role of these five departments, the universities should bear in mind that the probable upper limit of available enrolment for all five is 100 graduate students, and that the number of master's students currently enrolled outside the five stronger departments is 83; this leaves very few doctoral candidates.

Most of the justification for this recommendation has been given above, but we wish to enlarge here on some of the possibilities that we see are open. We strongly recommend that any of these universities which propose to continue in doctoral work select at most two areas which they can emphasize and in which they can achieve viable size, not forgetting the role of post-doctorate fellows. We also suggest that a small new programme is not impossible if arrangements with other nearby universities provide in a realistic way for some of the academic milieu that would otherwise be missing. We do stress, however, that such arrangements ought to have real substance and are likely to involve transfer of funds to compensate for the services of professors at other institutions. The members of ACAP believe that some exciting possibilities of this kind exist and urge the universities to explore them fully.

Recommendation C14

> It is recommended that McMaster, Ottawa, Toronto, Western and York plan for full-time enrolment for the next two years as indicated in the text, i.e. about the current enrolment or slightly more at the first four and an increase to about 30 at York, and that they be requested to report to ACAP the role that each department anticipates playing for the next five years, in terms of field emphasis, enrolment, and co-operative ventures with other chemistry departments.

The current enrolments (Dec. 1972) are McMaster 83, Ottawa 30, Toronto 77, Western 57.

It is anticipated that the re-assessments called for in this recommendation and C13 will involve some consultation amongst the chemistry departments. It is also suggested that the five departments named in this recommendation may find it useful to have some bi-lateral or multi-lateral conversations. When the reports requested in this recommendation are considered along with the proposals of those universities which decide not to discontinue their Ph.D. programmes, a revitalized system of chemistry doctoral work may be found to have taken shape.

It is difficult to foresee how rapidly the activity we envisage may occur. We therefore recommend:

Recommendation C15

> It is recommended that at least interim reports be made to ACAP by January, 1974, by each of the named universities on its action in connection with Recommendations C13 and C14.

If ACAP felt that any general action might be necessary as a result of these reports, ACAP would of course consult the Discipline Group and the universities before formulating any recommendations to OCGS or COU.

Recommendation C16

> No doctoral programmes additional to those resulting from Recommendations C13 and C14 should be contemplated in the foreseeable future. This recommendation should be reviewed in 1978.

Recommendation C17

> It is recommended that ACAP make a further report to COU on the provincial plan for graduate study in chemistry on the completion of the action called for in Recommendations C13 and C14 and in any case not later than May of 1975.

MASTER'S PROGRAMMES

The future of the M.Sc. programmes at Brock, Lakehead, Laurentian and Trent are determined by their universities' five-year plans, and we make no suggestions at this time. We expect chemistry M.Sc. programmes to be found in the other ten universities. We note with interest the York part-time programme, and suggest that this type of work may be of interest to school teachers in other centres, particularly if it had also a paedagogic component. The ACAP report on Education deals with MA(T) proposals.

ACAP has recommended approval of five-year plans for Brock, Lakehead and Trent. Those for Brock and Trent have already received ministerial approval. All of them include M.Sc. programmes in chemistry. The current enrolments are 7, 7 and 1 respectively and in each case a small increase is expected.

COU ACTION

Recommendation C18

It is recommended that COU adopt the recommendations of this report, inform CUA that it has done so and request that the embargo on chemistry be now removed, in accordance with the original announcement of the Minister that new graduate programmes would be embargoed until, for each discipline, a planning study has been conducted.

TABLE 1

FULL-TIME ENROLMENT IN CHEMISTRY

	Ph.D. Enrolment						Total Enrolment (M.Sc. plus Ph.D.)					
	67-8	68-9	69-70	70-1	71-2	72-3	67-8	68-9	69-70	70-1	71-2	72-3
Carleton	7	16	12	15	15	14	16	27	24	24	21	21
Guelph	2	4	6	11	7	9	17	16	24	35	23	16
McMaster	64	75	75	69	73	69	82	95	104	117	94	83
Ottawa	n.a.	29	30	27	28	24	n.a.	44	42	32	34	30
Queen's	41	47	40	43	38	28	73	72	70	58	49	42
Toronto	109	111	105	94	78	63	156	167	158	128	102	77
Waterloo	29	39	34	41	37	38	54	90	82	74	61	57
Western	61	55	53	63	56	48	78	81	74	85	65	57
Windsor	13	16	20	23	23	16	25	26	40	38	37	31
York	7	11	22	22	22	12	10	21	41	31	26	15
Brock							3	7	9	15	11	7
Lakehead								3	8	8	5	7
Laurentian										1	3	4
Trent							1	2	4	6	2	1
TOTAL	333 + Ottawa	403	397	408	377	321	515 + Ottawa	651	680	652	533	448

TABLE 2

FULL-TIME M.Sc. ENROLMENT

	Canadian First Degree	Non-Canadian First Degree	Total
1968 - 1969	127	121	248
1969 - 1970	157	126	283
1970 - 1971	134	110	244
1971 - 1972	93	63	156
1972 - 1973	n.a.	n.a.	127

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APPENDIX A

CONSULTANTS' REPORT

GRADUATE STUDIES AND RESEARCH
THE CHEMISTRY DEPARTMENTS OF THE
UNIVERSITIES OF ONTARIO

R. U. Lemieux, Chairman
F. Basolo
W. A. Noyes, Jr.
G. M. Volkoff

Submitted to the Advisory Committee on Academic Planning,
Ontario Council on Graduate Studies, Council of Ontario Universities
on March 23, 1973

FOREWORD

After having accepted the invitation to participate in a survey of the Chemistry Departments of Ontario Universities the four consultants in the course of their travels together and after considerable discussion among themselves selected for special attention those topics from their terms of reference on which they felt they had some hope of making a meaningful contribution, and chose to deemphasize others.

The primary topic to which they addressed themselves was graduate studies and research. No attempt was made to study in any detail the undergraduate instruction in chemistry in Ontario which on cursory examination seemed in any case to give no cause for concern. In this connection the remarks on tenure contained in the report refer specifically to those criteria which in the view of the consultants need to be emphasized by those departments which aspire to a successful and distinguished Ph.D. program. The fact that teaching ability as a criterion for tenure is not specifically stressed in the report does not mean that the consultants attach less importance to it. On the contrary, it is assumed that this aspect is automatically taken into account by all departments whether large or small and whether engaged in a Ph.D. program or not. Also no comments were included on the particular role the smaller institutions which offer only an M.Sc. degree at the graduate level can and do play in providing an alternative style of high quality undergraduate instruction. Finally, the consultants did not feel that their crystal ball for predicting future requirements for chemistry graduates at the B.Sc., M.Sc. or Ph.D. level is any less clouded than that of local authorities and chose to refrain from making any forecasts which they would be the first to disbelieve.

In the course of three separate one week itineraries all four consultants visited the ten Ontario universities which offer both an M.Sc. and a Ph.D. program, while each of the four smaller universities which offer only an M.Sc. program were visited by two of the four consultants. At each university discussions were held with faculty members individually or in groups. In most cases meetings with representative groups of students and Post-Doctorate Fellows were arranged. The consultants wish to express their sincere appreciation of the cooperation, courtesy and hospitality which were extended to them on all their visits.

Two meetings were held in Toronto with the Chemistry Discipline Group: one prior and one subsequent to the schedule of site visits. The figures in Tables II, III, IV, V, VI, VII, IX and X were revised to incorporate as far as possible the individual universities' own view of their situation. Undoubtedly some errors still remain, but since only qualitative conclusions were intended to be drawn, it is hoped that they are not seriously affected by any individual discrepancies.

The consultants bear sole responsibility for Tables I and VIII. It must be emphasized that the entries in Table VIII represent in the final analysis a consensus of qualitative value judgements of four individuals based to a considerable extent on data provided by an analysis of the N.R.C. granting procedure, but confirmed or modified by personal intuitive impressions gained in the course of site visits, and therefore incapable of being demonstrably justified in unequivocal quantitative terms.

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I. Summary

The report begins with an outline of the societal needs for graduate studies and research and of the commitments by society to universities and by university administration to chemistry that are required for the goals set to be reached. The basic commitment is adequate funding. In order to assist in assessing the financial requirements, a model for estimating the costs of graduate studies and research was constructed. This model is then employed as a basis to compare the investments represented by the various departments of chemistry.

The worth of the investment presented a particularly difficult problem. A major consideration was the ability of the departments to compete for grants-in-aid-for-research from the National Research Council of Canada. The compositions of the departments are considered in terms of specializations, age, distribution, and the areas of strength and weakness.

As the result of the assessments made and the consultants' views on such matters as the importance of graduate studies and research to the general welfare of chemistry departments, costs, minimum requirements for an acceptable Ph.D. program and policies for appointments, student admissions and tenure, thirteen recommendations are made for the period 1973-1983.

II. Basic Commitments Vital to Meaningful Graduate Studies and Research

A. The Commitment by Society

Any program based on public support must be relevant to the philosophical and pragmatic needs of the community that provides the support. There are many facets to this problem with the following perhaps being the most important and requiring positive action and firm priorities set by the community.

1. The community realizes and accepts a responsibility for the maintenance and improvement of world knowledge and includes the discipline of chemistry in this regard.

2. The community needs to demand the best intellectual environment that it can afford for the higher education of its talented citizens by realizing the importance of such activity for the general material and cultural welfare, economic independence and security of its citizens.

3. The community appreciates the high cost of the pursuit of knowledge at the best world standards and accepts the sacrifice necessary for its maintenance and promotion recognizing that chemistry, as a rapidly developing science, must play a central role in this activity and indeed is deserving of preferential treatment as one of the hard core subjects of human knowledge of direct relevance to its survival as a socioeconomic unit.

4. The community appreciates that the achievement of its goals must be in the control and trust of proven experts maintained in a competitive environment with external reference as to performance and guarded thereby against unwitting deterioration of standards.

B. Commitments Within the University

1. To develop with care powers for introspection that enable it to discern the real value of its activities through dispassionate, objective evaluation of the performance of its staff members.

2. To develop procedures for appointment and promotion which reliably accumulate thoroughly competent, dedicated and exceptionally talented staff members who are thereby fit to lead the intellectual elite of the society through teaching, but more importantly through example in the conduct by direct involvement of scholarly activities at the forefront of knowledge.

3. To maintain an administration that is appreciative of true scholarship and dedicated to the concept that those staff members, who possess a degree of expertise widely acknowledged by their peers outside the university and throughout the world as being relevant to the improvement of knowledge at the best world standards, are the mainstay of the university and that the maintenance of graduate programs is largely predicated to this end.

4. To maintain an administration that realizes through personal experience the great demands in talent, energy and drive required for the maintenance of scholarship at truly meaningful levels and is therefore sympathetic to and in support of those measures needed to ensure the necessary levels of performance by its professional staff.

Given the above indicated community with proper commitment of its politicians and an enlightened university administration from the Board to the president and to the level of deans, it is possible for a given department to aspire to a meaningful graduate program. In the absence of these basic commitments, it is best to do nothing since the existence of inferior programs for graduate study and research represents a hazard and handicap while being a serious drain on the economy.

To embark profitably on programs of graduate study and research also requires clear appreciation by those directly involved of their responsibilities (a) to the university (b) to the general community and, especially, (c) to the students enrolled in the program. These responsibilities can only be met under the following conditions.

1. The department has documentable reasons for believing that its staff members can provide a Ph.D. candidate with a truly meaningful experience in higher education. To do otherwise, especially to an inadequately talented student is tantamount to sentencing the individual to second-rate citizenship in his profession and to doing great harm to the community which becomes dependent on his professional services.

2. The department must have what is required in terms of staff and facilities to attract a substantial number of absolutely first-rate students. Student bodies, like departments, need leaders to set the standards for others (and to prod professors) and unless a university has acquired staff that can dependably attract excellence to its student body, it must not assume responsibility for graduate work, especially a Ph.D. program.

3. The department must have sound reason to expect that it is sufficiently well-based financially to provide the equipment, supplies, laboratory, shops and library needed for proper engagement of a Ph.D. program with adequate secretarial, clerical, technical and maintenance personnel to make the effort meaningful.

4. The department must appreciate and be mindful of the rather large financial burden placed on society by Ph.D. programs and to participate in such activity in a thoroughly responsible manner. The responsibilities go far beyond the personal stature and ambitions of the individuals involved - matters which are very secondary to societal needs in terms of the contribution of the Ph.D. program to quality teaching throughout the undergraduate programs of the university, the career and employment opportunities within the immediate society for at the least a substantial part of its graduates, the need (actual or anticipated) for the type of specialized expertise represented by its outstanding chemist-professors to local industry, government and colleagues in other disciplines, especially on campus.

III. Procedural Requirements for the Achievement of Excellence

Realizing the great trust and responsibility placed in it by society, a university department must organize itself for excellence whether or not it has a graduate program, only an M.Sc. program or a Ph.D. program. The demands, however, are particularly great for a department with a Ph.D. program. The central procedural matters which affect a department's ability to mount an acceptable Ph.D. program, once the department can justify this responsibility to society, can be enumerated as follows. However, prior to such enumeration let us underline that there exist many ephemeral matters which also have a large influence on the strength of a Ph.D. program but which are not susceptible to enumeration, yet, everything else being equal, can make the difference between excellence and utter failure. Here we allude to such matters as personality, selflessness, cooperation, dedication and friendliness which lead to an *esprit-de-corps* always found in at least the majority of the staff in any truly great department.

A. Appointments

Exceptionally talented, creative and properly motivated people have always been in short supply and this is especially the case in our highly developed society with its increased demands for an everwidening range of expertise. The field of chemistry has traditionally met with a high degree of success in drawing from this pool of rare individuals, but is steadily meeting with increased competition. The explosion in the training of scientists in the past twenty years, and the post-Sputnik promises of rewarding and exciting careers for self-expression to be found in science, have had the result that the recruitment for chemists has tended on a world-wide scale toward ever lowering levels of standards in native ability and motives in order to feed the Ph.D. factories of the 1960's. Whereas the chances of an employer gaining the services of a first-rate Ph.D. were excellent only twenty-five years ago, some large employers are now expressing concern that among today's recipients of the Ph.D. degree there is a considerable proportion of persons of lower quality. This casts a damaging inference on the kind of professional expertise which was promoted, with political consent, in the "hey-days" of the 60's. That, under the circumstances, these developments are understandable does not provide an excuse; that these be perpetuated would be inexcusable. The damage done to the profession is in part evidenced by the current backlash to the promotion of industrial research. The point here is that acceptably good people are hard to find and the situation is not made simpler by the fact that a prospective employer who now advertises a university position invariably receives several hundred applications. In such situations, inevitably, pressures based on considerations other than promise as a scholar (e.g., nationality) arise which only compound the problem. The fact remains that the seeking and finding of new appointments to staff is the "cornerstone" of a graduate program. More and more this responsibility is being eroded by delegation to committees (organizational eunuchs which were invented to avoid the stigma of direct responsibility). Even students now demand participation in matters which challenge the expert. Therefore, the future of scholarship in terms of defended contributions to knowledge which have had a measurable effect as assessed by experts on the improvement of knowledge, appears in serious jeopardy. As will be seen later on in connection with an analysis of the success rate in applications for N.R.C. grants amongst younger tenured staff in Ontario universities, the degree of erosion already extant appears to be cause for alarm. Therefore, the consultants wish to stress that the most important single factor in the matter of appointments is the departmental leadership. Strong departments can only be built through the attention of strong, properly motivated leadership; strong departments can only be maintained and promoted through strong responsible leadership.

A department involved in Ph.D. studies must have a number of outstanding individuals who clearly possess strong international reputations as leaders in their field. The consultants consider that the staff of such a department must number at least fifteen and an acceptable distribution would be six full professors, four associate professors and five assistant professors. Of the six full professors at least four should be outstanding and specialized in no more than two areas of chemistry, and these areas for such a small department would represent the main strength of the department. The other two full professors should have strong reputations to help balance the department. There can be little excuse for the four associate professors not showing every indication of developing into leaders and at least two of these should be buttressing the two core specialities of the department. The assistant professors should be so chosen to be best to meet the future plans of the department taking into consideration the ever changing challenges of chemistry. The demands on performance from assistant professors should be highly exacting with special attention to the detection of the marks of a personal need for true scholarship that will naturally continue without external stimulus should tenure be granted. More will be said later on about the granting of tenure, perhaps the most crucial single matter in developing a strong department but which appears to have become misused in Ontario universities, as elsewhere, in recent years.

Responsible engagement in making permanent appointments takes into consideration not only breadth of expertise but also age distribution with a modest, conservative expectation for increase in the growth of the number of faculty. It is far easier to adjust from an under-estimation in this regard than from unrealistic plans based simply on ambition for expansion. The universities of Ontario have largely erred badly in this regard and the situation is now serious.

The department of fifteen full-time teaching staff members proposed as minimal for a viable Ph.D. program is expected, because of its size, still to be in a growth period. Thus, a reasonable expectation could be for the department to increase its staff to 25 by 1983. Control on age distribution must be consciously exercised throughout the 10-year period if the consequences are to be avoided,

(a) of unacceptably high payrolls for reasons of too many full professors,

(b) of a lack of opportunity to change the department's emphasis in expertise as the development of chemistry dictates and, most importantly,

(c) of the lack of an ability to maintain a steady, meaningful influx of young people.

Responsible leadership will use every occasion to control age distribution. The opportunities to do so occur,

(a) at hiring,

(b) at the granting of tenure, and,

(c) in the measures taken to keep staff who have offers from elsewhere.

In general, the long-term welfare of the department should take precedence over the services of a given individual.

B. Promotion and Tenure

The worth of a department of chemistry as an effective organization for the pursuit of knowledge will hinge more on its attitude toward the granting of tenure than any other single factor affecting academic performance. It is useful to keep in mind that the granting of tenure to a first-rate individual normally establishes that the department warrants the attention of such an individual.

The basic philosophy behind the granting of tenure is to provide a gifted scholar and teacher the opportunity to plan and accomplish a career in a highly specialized area at the frontiers of knowledge without undue encumbrance with matters related to job security. It must always be kept in mind that many such people on reaching the age of about 35 have become so specialized in areas of no concern to business or government that they have become virtually unemployable, at levels compatible with their expertise, for other than teaching and fundamental research. Thus, an organization that requests people to so specialize in the pursuit of knowledge has an obligation to these people in terms of job security. Assuming this responsibility, the organization must then make its best effort to insure that the tenured appointment best meets the long-term needs of the department.

The presence of demanding tenure regulations in a department has many salutory effects on the overall performance of the department. First of all, it makes departments very careful about initial appointments since there is always stigma attached to having hired badly, and having therefore, to deny tenure later on. The pressure of the requirement for accomplishment on the person seeking tenure ensures dedicated concern with scholarly work by the individual from the beginning of the appointment. Such activity in turn has a stimulating effect on the remainder of the staff as a result of the opportunity provided to associate with gifted and highly motivated *younger* people.

The initial term appointment leading to the consideration for granting of tenure must not be too short. It is simply unrealistic to expect a young person to make a mark in less than five years as an independent and effective scholar in as complex and competitive area of human knowledge as is represented by chemistry. Indeed, seven years is much more acceptable. Shorter periods are basically unacceptable since these amount to sheer unfairness to the person under consideration. This applies especially to appointments in strong departments where, from the beginning, the person was made to understand that he could expect tenure. In the absence of a 5 to 7 year trial period, the person should simply be hired under contract for a limited term only with no expectation for tenure.

It must never be forgotten, that a main purpose of Ph.D. programs is to attract bright young people to become engaged in research with staff members and thereby help keep the staff professionally alive. In turn, young assistant professors, pushing for tenure through accomplishment, help prevent the tenured staff from going to seed. The striving for excellence is a continuing uphill battle and university departments rise or fall depending on how well this basic law of life is appreciated. Deploring the work ethic accomplishes nothing except the deterioration of the morale of those involved.

Certain of the Ontario universities do not appear to appreciate the concept of challenge as basic to human development and it is always deplored by those who have failed in the system--those who naturally will always be in the majority.

This constitutes a threat now being faced by most universities in the Western World. Fine universities can exist only through continuing demonstration of excellence at best world standards. Changing fashions based on emotion and current levels of affluence can and do entertain mere competence but the cost of mere competence will inevitably prove too high. The public that pays the bill sooner or later will withdraw its support. Excellence is the only endurable road to security.

Some Ontario departments of chemistry, in the face of pressure by student bodies and by organizations of those who have failed in research appear in recent years to have renounced their responsibility to work towards acceptable standards for the granting of tenure. This in part was also likely due to immaturity of leadership in a time of rapid growth. The attitude was expressed that this would be made up for by denying promotion to full professorship. Certainly, there is a case for career appointments at the top of the associate professorship level. However, this is the worst possible way of planning a department. The occurrence of such appointments must be considered a failure and departments should not plan for failure. There are only three legitimate reasons for tenured staff in due course not achieving full professorship at a given university, ill-health, death and an inability of the department to keep the individual's services. Proper planning must be based accordingly.

C. Working Conditions

Having discussed appointments and promotions, a consideration of facilities seems redundant. Clearly, except under the most dire circumstances, people truly deserving of the opportunity and privilege to become university

Professors will not sacrifice their careers by joining a department that cannot offer acceptable conditions of employment in terms of providing the facilities required for productive research and effective teaching.

The position must carry a formal teaching load compatible with scholarly effort and provide a back-up in terms of library, computer, shop and technical services compatible with competitive effort in research. Furthermore the university must be prepared to accept, as overhead charges, very considerable expenditures related to research activity which at least in the Canadian context, cannot reasonably be met by the staff member through grants-in-aid-of-research from other agencies. Such contributions include the provision of assistance to graduate students through teaching assistantships which are remunerated at meaningful levels, the provision of supplies and sundries for research and adequate stenographical, drafting and reproduction services. Furthermore, the universities should plan to be of financial assistance in the purchase, installation and maintenance of specialized equipment necessary to the research programs but for which only partial outside support can normally be obtained.

IV. Compositions, Sizes and Costs of Departments of Chemistry

A. Hypothetical Financial Model

The name of this game is money. Basically, the consultants are asked to provide their collective opinions on

(a) how much the Ontario government should spend for graduate studies in chemistry,

(b) to what purposes and how well has the money been spent in the past, and,

(c) what should the "game plan" be for the future.

However, no information directly relevant to these matters was provided for assessment. Undoubtedly, this omission was not accidental. Nevertheless, the consultants cannot render the service expected in the absence of an appraisal of costs, if not absolute then at least relative costs. The plan therefore was to create a financial model for an Ontario university and to compare the various Ontario universities on the basis of this hypothetical model. The various assumptions made in this regard are summarized as footnotes to Table I and are based on an examination of the data provided on Ontario chemistry departments.

Perhaps, needless to say, no high degree of precision can be or is expected from the use of the various approximations made to anticipate costs. Nevertheless it is hoped that the procedures used provide at least a fair basis for relative comparisons and an acceptable framework for the appraisal of absolute costs.

The footnotes to Table I describe a model for the estimation of costs for the establishment and operation of chemistry departments. The relationships used are all arbitrary but chosen in such a way that they will reflect the Ontario departments in so far as populations are concerned in terms of undergraduate classes, courses, full-time teaching staff and graduate students. The cost factors are based on ordinary experience and appear to find support in that they yield good "ball-park" figures. The exercise of producing this model will be considered worthwhile if it accomplishes nothing more than to cause the various departments to demonstrate where and how the model is deficient. Thus, the object of the mission requested by ACAP would be largely accomplished.

TABLE I

Model Devised for the Assessment of Costs of Graduate Studies and Research

				Part-time Teaching Staff				Costs per annum			
	A	B	C	D	E	F	G	H	I=G-H	J=H/A	K=I/F
	No. Courses	No. Classes	No. Full-time Staff	Sessional Lecturers ≈A/240	Full-time G.T.A. Equivalents ≈A/60	Total No. Grad. Students	Total $	For Undergraduate Teaching	For Graduate Teaching	Per Undergraduate Course	Per Graduate Student
1.	400	15	9	2	-	-	$ 308M	$ 308M	-	$ 770	-
2.	400	15	9	-	8	12	420M	308M	$ 112M	770	$ 9,333
3.	1000	24	15	4	-	-	520M	520M	-	520	-
4.	1000	24	15	-	16	24	720M	520M	200M	520	8,333
5.	1000	24	15	-	16	32	920M	520M	400M	520	12,500
6.	1800	31	28	-	30	60	1720M	971M	749M	539	12,480
7.	1800	31	33	-	30	90	2220M	1131M	1089M	628	12,100
8.	2400	34	33	-	40	80	2120M	1156M	964M	482	12,050
9.	2400	34	41	-	40	120	2840M	1412M	1428M	588	11,900
10.	3000	37	38	-	50	100	2520M	1341M	1179M	447	11,790
11.	3000	37	47	-	50	150	3380M	1629M	1751M	543	11,673
12.	3600	40	44	-	60	120	2960M	1558M	1402M	433	11,680
13.	3600	40	56	-	60	180	4040M	1942M	2098M	539	11,656

Footnotes on following page.

Entries 1 and 3 correspond to institutions offering no graduate work.
Entries 2 and 4 correspond to institutions offering an M.Sc. degree only.
All other entries correspond to institutions offering a Ph.D. as well as an M.Sc. degree.

Footnotes to Table I

A. Numbers arbitrarily set for demonstration purposes.

B. Based on the number of courses and the trend in Ontario universities and which follows the plot of no. of courses vs. no. of classes quite well.

C. From the expressions

(a) No. sessional lecturers = $\frac{\text{No. of courses}}{240}$ and

One sessional lecturer = 4 full-time Graduate Student Assistants (G.T.A.'s)

(b) For an M .Sc. granting department, the total number of graduate students is taken as approximately

1.5 x (No. of full-time G.T.A.'s) for entries 2, 4

(c) For a Ph.D. granting department, the total number of graduate students is set at a minimum of

2 x (No. of full-time G.T.A.'s) for entries 5, 6, 8, 10, 12 and at

3 x (No. of full-time G.T.A.'s) for entries 7, 9, 11, 13

(d) No. of full-time staff (for entries 6-13)

$$\approx \frac{\text{No. of classes}}{2} + \frac{\text{No. of Graduate Students}}{5}$$

For entries 1-5 arbitrary average Ontario figures of 9 and 15 are used.

D. & E. See footnote C (a), above.

F. See foonote C (b) or C (c), above.

G. (a) For non-research departments (entries 1 and 3),

Total cost = \$32,000 x (No. full-time staff) + \$10,000 x (No. sessional lecturers)

[\$32,000 = \$20,000 x 1.6]

(b) For an M.Sc. granting department (entries 2 and 4),

Total cost = \$40,000 x (no. full-time staff) + \$5,000 x (No. graduate students)

[\$40,000 = \$20,000 x 2.0]

(c) For a Ph.D. granting department (entries 5-13),

Total cost = \$40,000 x (No. full-time staff) + \$10,000 x (No. graduate students)

H. Cost = \$32,000 x (No. full-time staff) + \$2,500 x (No. full-time G.T.A.equivalents).
(cf. G (a) and C (a))

I. Cost in footnote G minus cost in H.

J. Cost in footnote H divided by the number of courses (A).

K. Cost in footnote I divided by the total number of graduate students.

Before entering into an appraisal of the universities, based on the model, it seems best to examine the model itself and draw the guidelines that it appears to provide.

Entries 1 and 2 of Table I are made in order to assess the cost of operating a straight teaching department (entry 1) versus one engaged in research at the M.Sc. level (entry 2). The numbers of courses, classes and full-time teaching staff were chosen to correspond roughly to the four M.Sc. granting departments. The model suggests that research compatible with the M.Sc. degree that would involve twelve students and provide an opportunity to nine member of the staff to be directly involved in scholarly work would cost about $112,000 (this amount does not involve outside support). It is suggested that this is a very acceptable investment to make if only to insure the academic standards of such a department. Of course, many other benefits accrue in terms of the research training provided, and the research accomplished. The main criticism of schools of this size is the apparent inherently high cost of undergraduate training.

Entries 3 and 4 are made mainly to suggest that the offering of 1,000 courses is needed to bring these costs in line with those of highly developed major departments. Entries 2 and 4 indicate that the cost per year of maintaining an M.Sc. graduate student is about $9,000 which is only about $3,000 less than in a Ph.D. program.

Entry 5 is of particular importance since it refers to the borderline between an M.Sc. and a Ph.D. granting department which is set in this report. At the level of about 1,800 courses (entries 6 and 7), the cost of an undergraduate course is close to the nearly irreducible number of $500 and the annual cost of producing a Ph.D. is near that of larger departments. Most importantly, the required staff to offer the necessary range of expertise and facilities is quite acceptably reached. The projections for the population growth of Ontario is about 25% over the next nine years. It is suspected, therefore, that the required undergraduate base for entering into Ph.D. work may not be reached in that time by the departments now limited to M.Sc. programs.

The remainder of Table I is to indicate that the cost of a Ph.D. program per graduate student is not appreciably affected by increasing the size of a department. However, the data is presented in such a way as to suggest that increases in the number of Ph.D. students from double to triple the number of full-time G.T.A.'s (cf. entries 8 vs. 9, 10 vs. 11, 12 vs. 13) materially increases the cost of an undergraduate course offering (about $100). This is expected to result from the need for increased full-time teaching staff to manage the increased research activity and the involvement of this added staff in the undergraduate program. Improved standards of presentation result for the increased number of undergraduate classes, but the cost is also increased. It is suggested that when the number of graduate students registered becomes greater than double the number needed as teaching assistants, then the cost either of undergraduate courses or of graduate work begins to increase substantially and that growth beyond this point needs particular justification. The employment of postdoctoral fellows based in part on research grants is probably the sounder way of increasing the department's teaching and research programs especially now since the demand for new Ph.D.'s appears to be in a period of uncertainty. The productivity in terms of the research dollar is much greater for postdoctoral fellows and these bring a very beneficial broadening of experience to the research group. Based on the model, the Ontario chemistry departments in 1971-72 were about 10% short of double the estimated G.T.A. requirement.

B. Rationale for the Model and Possible Relationships to the Departments

1. Academic Staff

The average salary for full-time teaching staff is taken as $20,000 per year. The amount may be substantially higher in well-developed departments with an age distribution skewed toward the older side. The amount may be too high for small newer colleges, especially those which have only an M.Sc. program. Nevertheless, it is a convenient round figure for the present purpose of establishing a framework for the comparison of the various departments while producing numbers that are expected not to be totally unrealistic.

2. Graduate Teaching Assistants and Sessional Lecturers

It is assumed that one full-time graduate teaching assistant can be properly employed for about each 60 courses taken by undergraduate students (20 students in each of 3 classes). If the number of graduate students registered in the department cannot meet this requirement, then it is assumed that sessional lecturers or teaching postdoctoral fellows will be employed to fulfill the teaching responsibility involved. The remunerations for an academic year are assumed to be $2,500 for a full-time graduate teaching assistant (9 hrs.) and $8,000 for a sessional lecturer (36 hrs.) for about eight months per year or an annual salary (if full-time) of $12,000. An average figure of $10,000 is used in foonote G(a) to Table I.

It is assumed that a full-time member of the teaching staff cannot properly maintain his professional standards through study, writing and research, effectively participate in departmental and community affairs, properly prepare and present the formal lecture and laboratory courses and do the necessary student advising and tutorials while presenting more than two full classes. Furthermore, it is assumed that this undergraduate teaching load must be reduced with increasing involvement in graduate studies in order to liberate time for the presentation of graduate courses*, the supervision of graduate students and their research, the maintenance of shop and service facilities which are required for graduate work and a host of responsibilities that arise as a result of published scholarship which are too numerous to be mentioned but which include outside lectures to universities and learned societies, consultation for industry and government, publication of research both counting the faculty member's own and the time and effort spent in criticizing that of others. The full-time teaching personnel involved in graduate studies normally work a minimum of 50 hours per week. Over 60 hours per week is not uncommon. It is assumed that a valid *guide* for assessing the average teaching load in a chemistry department in terms of teaching staff per class presented is that presented in footnote C to Table I. A course is taken as 3 lectures per week over the academic year and has on the average a 3-hour laboratory. Any deviations from this laboratory requirement are neglected.

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* A Ph.D. program involves about 10 graduate courses per year and an M.Sc. program about 4 graduate courses per year.

Table II appears to illustrate the validity of the above rules for Ontario. It is seen that the correspondence of the predicted number of staff required to conduct the undergraduate teaching properly with that which actually exists is in most cases very good. The only glaring disagreement is in the case of Ottawa which appears to be seriously understaffed.

3. Fixed Overhead Costs

The proposals made herein regarding undergraduate overhead costs are at best rough rules of thumb. As a start, it seems useful to note the major items involved in these expenditures.

(a) Salaries of administrative and secretarial personnel including contributions to health-care and retirement plans, insurance, sabbatical leaves and travel.

(b) Portions of the budgets for central library, computing, shop and general service facilities.

(c) Salaries for departmental support personnel such as storekeepers and technicians.

(d) Supplies and sundries for teaching and administration including the necessary equipment and its maintenance.

(e) General building and ground services and maintenance including ground keepers, janitors and outside contractors together with the costs for heat, gas, water and electricity.

(f) Perhaps amortization and interest payments on loans to acquire building and other capital investments.

The assessment of fixed overhead costs for a university department is very difficult and is only rarely attempted. For the present purposes this cost will be assumed to be 50% of the total payroll for full-time teaching staff. This cost is set on the basis of general experience in related but business areas.

TABLE II

Comparison of Teaching Staff (1971-72) with Model Calculations

UNIVERSITY	FULL-TIME STAFF		Actual No. of Classes	GRADUATE ASSISTANTS		Actual No. of Under-graduate Courses
	Actual No.	No. according to model		Actual No. of Graduate Students	No. of Full-time G.T.A.'s according to model *	
1. Universities Offering Both M.Sc. and Ph.D. Degrees						
Carleton	18	19	28	26	20	1151
Guelph	27	24	33	33	42	2473
McMaster	27	33	31	86	30	1819
Ottawa	13	22	30	34	30	1816
Queen's†	26.7	25	32.5	44.5	31	1883
Toronto:						
a) St. George	28.7	35	33.5	93	47	2793
b) Combined	38.2	47	53.5	103	59	3560
Waterloo	33	**	**	65	42	2550
Western	31	31	34	70	42	2512
Windsor	15	20	25	39	20	1196
York †	24	23	25	50	25	1513
2. Universities Offering M.Sc. Degrees Only						
Brock	10	10	15	12	8	500
Lakehead	10	11	19.5	7	11	650
Laurentian	9	9	16	6	6	360
Trent	7	10	17.5	4	4	241

* Or the teaching postdoctorate or sessional lecturer equivalent. Such appointments will probably be necessary when the total number of graduate students is appreciably less than double the required number of graduate teaching assistants.

** Model not unambiguously applicable to three term operation.

† The data is for 1972-73

4. Costs for General Upgrading of Facilities

It is assumed that the annual cost for upgrading of the general facilities for a department is 10% of the payroll for full-time teaching staff. Again, this rule is based on experiences of a similar nature but where accounting is possible.

5. Costs for Research

It is assumed that the costs for research are usefully approximated by 40% of the annual full-time teaching staff payroll plus $5,000 per year per graduate student when the university is limited to an M.Sc. program. The latter amount is doubled if the university conducts a valid Ph.D. program. There appears to be no reason to differentiate between the cost for an M.Sc. student and a Ph.D. student when both are registered in a Ph.D. granting institution. The stipends for graduate teaching assistantships are absorbed in these amounts. The rationale is that normally the holders of G.T.A.'s are heavily involved in formal course work and their actual research costs are less than for graduate students doing full-time research.

For the purpose of this assessment, it is assumed that the salaries for graduate students and postdoctorate fellows in excess of the teaching requirements of the undergraduate student body are met from scholarships and outside grants to the professors involved. As is normally done, no account is taken of the overhead costs for postdoctorate fellows. Nevertheless, these costs are real and need to be reflected somewhere. It is assumed that the estimated overhead cost for the graduate students covers this expenditure and, in a way, is a bonus for a well run research operation, especially from the returns in interest on investment of the grants received by the university. As indicated above, the overhead cost for graduate students is assumed to be $10,000 per year in a Ph.D. granting department but $5,000 per year for a department limited to an M.Sc. program. These amounts are considered not to be extravagant since they are on the low side of the figures provided by many detailed efforts in this regard (see later on regarding Table III)

It is probably worthwhile noting at this point some of the major sources of expenditures by a university for the maintenance of research programs.

(a) Increased full-time teaching staff.

(b) Improved central library and computing facilities.

(c) Increased secretarial and administration costs.

(d) Budget allowances for supplies and sundries to assist research and capital equipment costs and their maintenance.

(e) Additional personnel and facilities for departmental services such as stores, electronics, glass-blowing, machine shop, drafting and reproduction, analytical and spectral determinations.

(f) Provision of research laboratory space and the additional costs in services (heat, electricity, gas and water).

(g) Likely additional travel and entertainment allowances.

Estimates made on the foregoing bases lead to the costs, given in Table III, for the 14 Ontario universities being examined.

The total costs in Table III are arrived at using the formulas given in foonote G of Table I.

Prior to a discussion of the inferences contained in Table III, it seems best to consider the costs involved for research. In theory, the various universities could be stripped of their research facilities. The teaching assistance would then be provided either by full-time teaching staff only or by full-time teaching staff plus sufficient sessional lecturers to make up for the loss of graduate teaching assistants. The latter course would provide an important saving but can only be seriously entertained in small schools where only 2 or 3 sessional lecturers are required. In a large school which employs, for example, 40 graduate teaching assistants, their replacement by sessional lecturers would require 10 such part-time appointments. These appointments should be for no more than a three-year period since otherwise the sessional lecturers assume a role of second-rate citizenship in the department. More importantly, should such a large portion of this second-rate teaching staff become essentially permanent, the only opportunity to bring fresh experience to the department would be lost. For these reasons, it is neither practical nor academically sound to fill all teaching positions either with full-time staff who are eligible for tenure or with sessional lecturers on limited term contracts. Nevertheless, the savings that would be involved in doing so seemed worth estimating so as to gain an appreciation of the costs involved in maintaining a research activity at the M.Sc. level.

The number of sessional lecturers is taken as one-quarter the number of required graduate teaching assistants. The results of calculations of costs without research using formulas of footnotes G(a) or H of Table I are given in Table III. Research costs are then obtained by subtraction. It has often been estimated on a number of different bases that the cost of producing a Ph.D. in the U.S. is about $15,000 per annum. The costs arrived at in this regard and given in Table III lend credence to the procedures used in making these estimates.

TABLE III

Estimates of Annual Costs for Research, 1971-72, Based on Model

(Actual budgets were not provided)

UNIVERSITY	Present Total Cost	Cost Without Research	Cost Per Undergraduate Course	Cost of Research	
				Total	Per Graduate Student
1. Universities Offering Both M.Sc. and Ph. Degrees					
Carleton	$ 980M	$ 626M	$ 545	$ 354M	$ 13,615
Guelph	1,410M	969M	392	441M	13,364
McMaster	1,940M	939M	516	1,001M	11,640
Ottawa	860M	491M	270	369M	10,850
Queen's	1,513M	933M	509	580M	13,020
Toronto:					
a) St. George	2,078M	1,036M	371	1,042M	11,200
b) Combined	2,558M	1,370M	385	1,188M	11,530
Waterloo	1,970M	1,161M	455	809M	12,420
Western	1,940M	1,097M	437	843M	12,040
Windsor	990M	530M	445	460M	11,800
York	1,460M	830M	549	630M	12,600
2. Universities Offering M.Sc. Degrees Only					
Brock	$ 460M	$ 340M	$ 680M	$ 120M	$ 10,000
Lakehead	435M	343M	528	92M	13,140
Laurentian	390M	303M	685	87M	14,500
Trent	300M	234M	971	66M	16,500
TOTAL:	$17,206,000	$10,166,000		$ 7,040,000	

6. The Undergraduate Base

It may be noted that, as would be intuitively expected, the costs for graduate research are not appreciably less in M.Sc. granting departments and the most economical procedure for the presentation of undergraduate courses is in large universities which have a large relevant undergraduate base. Those who proliferate universities should take notice of this fact.

V. Regarding Academic Excellence

A. The Supply of Graduate Studies

The consultants were requested to examine the 14 Ontario universities with reference to graduate studies in chemistry, report on their findings and make recommendations for the development of graduate work in chemistry in Ontario between 1973 and 1983 but in more detail for 1973 through 1978.

The central problem brought to the consultants' attention is that the sum of the projected aspirations for Ph.D. programs in the graduate departments of Ontario appear to far exceed the market requirement.

The consultants maintain the point of view that, especially since graduate work in Ontario is now extensively developed, regardless of the employment opportunities for Ph.D.'s, a consideration of the quality of the Ph.D.'s graduated remains more important than their numbers. The basic reason for the adoption of this attitude is that there exists no realistic basis for anticipating (within a reasonable range with acceptable precision) the needs of Ontario, or of Canada (and also, of Canada's appropriate future contribution to world needs*) for highly trained chemists of the Ph.D. calibre. Canada has been termed the world's most affluent under-developed country. There is a strong element of truth in this statement--a matter which further greatly complicates any attempt at a realistic projection of the needs for chemistry Ph.D.'s. Canada must be expected to become increasingly dependent on indigenous (in contrast to imported) technological developments and companies for an acceptable level of survival and the role to be played by appropriately selected and trained chemists must not be underestimated. Furthermore, proper Ph.D. programs have had a remarkable success in meeting a broad spectrum of career objectives and societal needs and conceivably may prove valuable (at least suitable) in a widening range of future demands.

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* In this regard, the high dependence on imported talent to meet the previous needs of Ontario should be noted. Thus, 53% of faculty members in Ontario chemistry departments received their first degree abroad (mainly the United Kingdom) and 65% obtained their Ph.D.'s (98% have a Ph.D. degree) outside Canada. The situation is expected to be similar for Ph.D.'s employed by industry and government.

Although the core of the Ph.D. program must be to prepare the student to conduct scientific research in the field of chemistry, there cannot and will never exist a guarantee of a position in the exact field of the recipient's field or even as a research chemist. Those entering graduate work must have a clearer understanding of this situation and the increasingly competitive nature of the profession and be prepared, if need be, to make careers in a variety of fields into which chemists often move, normally spontaneously, in response to changing circumstances.

For the above reasons, the consultants are not enthusiastic about predicting the markets for Ph.D. chemists in 1973-1983. Instead, this report will concentrate on the quality of the Ph.D. programs now being offered and the opportunities for improvement where these seem to exist.

The consultants can readily agree through only superficial examination that there can be no rational basis for more Ph.D. programs in Ontario. The problem is seen as one of assessing the quality of those in existence and making recommendations on their needs for improvement and/or curtailment. It will become apparent that the aspirations of some departments may have become unrealistic and that certain universities with new or weak programs must question whether or not it is still feasible for these to continue. The reasons given will be based mainly on academic considerations but reference will be made to costs for improvement and the likely return to be derived from such an investment.

The consultants firmly believe that the future of the Ph.D. programs in Ontario, as elsewhere in Canada, will rest more on the available number of suitable Canadian students than on all other relevant factors combined. The number will be determined by various circumstances beyond the absolute number of properly qualified and suitably talented students and, in a free country, decided on by the students themselves. The considerations will include the quality of the research programs available in the competition for the best students from universities outside Ontario both in Canada and in other countries and, of course, the state of the economy of the country as it reflects on the cost of the educational experience (availability of financial assistance) and on its probable worth on graduation as assessed by the student in meeting his or her ambitions for a rewarding career.

The central fact is that there exists a definite ceiling for high quality and successful graduate programs which any free society must face and this is the number of acceptable students who elect to enter the programs. It is beyond debate that the 1960's saw a period when Ontario universities, in common with other universities both in other parts of Canada and abroad, admitted large numbers of graduate students not only under-qualified but basically under-talented in terms of demonstrated independence, imagination and creativity in problem solving. The 'need' for graduate programs basically arose because the demand for Ph.D.'s far exceeded the supply in the early 1960's. However, the decisions to increase the number of Ph.D. programs in Canadian universities from 4 in 1952 to 35 in 1972 and in Ontario from 2 in 1952 to 10 in 1972 were rationalized to meet not only this demand but, also, the presumed requirements for the expansion of the undergraduate programs both in old and new universities, and the demands arising from the pressure on departments to produce graduate students in order to attract and keep faculty, from the pressure on professors to be productive in research for advancement and, especially in Ontario, from the enhanced value of graduate students to overall university finance. These and other factors contributed to a lowering of standards of admission to Ph.D. programs.

Great credit must be given to the Committee of Chairmen of Departments of Chemistry of Ontario Universities (CCDCOU) for recognizing early the dangers inherent in indiscriminate expansion and for taking concerted action to raise and voluntarily maintain a uniform standard of admission at a B+ average.

The Canada-wide relaxation of admission standards in the sixties was serious enough for Canadian students but particularly deplorable for aliens who, as a result of their educational experience, became essentially displaced persons in Canada. These matters will be dealt with in greater detail later on in this report where it will be seen that already strong measures have been introduced to eliminate these abuses of opportunity for graduate studies.

Substantial growth in graduate work in Canadian universities over the past twenty years was of course inevitable. In 1952, the country was very seriously underdeveloped in this respect and there existed serious reason to doubt that what existed was at acceptable world standards. To remedy this situation was the first challenge accepted by N.R.C., under the courageous and wise leadership of the late President E. W. R. Steacie, in the overall strategy then entertained by N.R.C. in meeting its responsibilities for upgrading the standards of science and technology in Canada. The untimely loss of his leadership in 1962 led to much of the regrettable bewilderment and amateurism regarding science policy in Canada over the past ten years.

In summary, although the number of graduate students admitted to the Ontario system of chemistry departments has decreased by more than 50% in the past four years, this must not be considered a permanent swing away from Ph.D. studies. There undoubtedly was too large an admission rate in the mid-1960's and the product which has just recently emerged is definitely experiencing problems in finding relevant employment. However, the situation does not appear to be nearly as alarming as some would make it out to be and, indeed, the situation appears to have ameliorated very substantially since the beginning of this assessment in mid-1972. To an appreciable extent, this amelioration was brought about by Ph.D.'s entering the secondary school system. This development alone can be considered to justify the overproduction beginning in about 1965 since it can legitimately be expected to have a highly beneficial and much needed effect on high school education which probably could not have been achieved in any other way. These considerations aside, to choose this time in Canada's history to deliberately throttle down Ph.D. production in chemistry must be considered sheer folly. In fact, on listening to the Speech from the Throne by the new government at the time of this writing (January 4, 1973), one could not but be impressed on how much the government must depend on the strength of Canadian chemistry to meet its aspirations in terms of new Canadian enterprise. Indeed, since the beginning of this assessment, the Canada Development Corporation, created in 1972, has begun the acquisition and financing of enterprises aimed at creating for the first time major efforts based on Canadian innovation and under Canadian control for the provision of such chemically related industries as a national pharmaceutical company, renewed efforts in polymer production coupled with new enterprises in petrochemicals and professed interests in the development of Canadian sources for specialty, fine and commodity chemicals. This is the dawning of a new era for Canadian chemistry which promises for the first time to justify properly its past investments in higher education and thereby to bring just rewards to young Canadians willing and able to assume leadership in chemistry. The experience of the past ten years has not established that Ontario (and Canada) has over-emphasized graduate studies and research in chemistry. It is expected that the next ten years will show a handsome return on the investment to build the necessary plant and to acquire the generally excellent staff but only if the work is done at the very highest world standards. There will be much room at the top and we beseech the Ontario government not to quit at this crucial time.

B. Assessment of the Quality of Graduate Programs in Chemistry in Ontario

1. Criteria for Excellence

The Committee on Professional Training of the American Chemical Society has recently published a report entitled "Doctoral Education in Chemistry: Facing the 1970's" (1). The hallmarks of a good program presented can be summarized as follows:

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(1) Chemical & Engineering News, August 14, 1972, pp. 35-39

(a) The department should have an adequate number of staff members to achieve an adequate breadth of interests and to develop the essential facilities. The staff should be about 20 or more in number.

(b) The competence and ability of the staff is critical. A successful department needs at least several members who are recognized leaders in their field--and these realities render each tenure decision of major importance.

(c) As there is a critical size for the faculty, there are closely related critical parameters for facilities and operating budgets in terms of glass-blowing, machine and electronic shops, technical service laboratories, computer capabilities and library facilities. Generally, the establishment of the first two criteria is a precondition for adequacy in this regard taking into account cost effectiveness.

(d) A critical number of graduate enrollments is required and this is most reliably found in departments where the research competence of the faculty is acknowledged to be strong. The indications are that a staff of at least 20 is desirable and the Ph.D. production to be not far below 15 per year.

The consultants subscribe to the views of the A.C.S. Committee, except as was indicated with reference to the minimal Ph.D. program, a full-time teaching staff of 15 and a Ph.D. production of 10 per year is considered acceptable although barely so. Therefore it was considered imperative that this report provide an assessment of the number, competence and interests of the faculty of the chemistry departments of the Ontario universities. The number of faculty and interests at a given time is a trivial matter to establish with precision. However, to achieve a substantially objective assessment of the competence and how the competence is spread across the areas of interest to chemistry is a problem for which there is no neat solution. Even to achieve a useful approximation would be extremely difficult and could not be achieved by the consultants on their own. However, the system of grants-in-aid-of-research used over the years by the National Research Council of Canada provides as reliable a measuring stick for this purpose as can reasonably be expected.

The rather unique approach to granting used by N.R.C. has centered on the proven competence of the individual. The evaluation of the individual pays no regard to funding received from other granting agencies and pays little heed to the nature of research interests.

The above-mentioned A.C.S. Committee (1) concluded, "no graduate department can expect to survive unless it has a very substantial commitment from its own institution not only for salaries for faculty and teaching assistants, but also for library replenishments, for shops and research services, for the purchase and maintenance of instruments and for many of the direct research costs themselves, particularly for younger faculty who cannot yet compete successfully for grants." N.R.C. never pretended that, in making operational grants, it was meeting more than a portion of the total costs of the research but relied on the grantee's institution to make a substantial additional contribution.

Evidently, then, the better the local support, the better the position of the grantee to compete for the N.R.C. funds. Universities capable and willing to supplement the faculty members' grants-in-aid-of-research to the extent required for a strong graduate program could then expect its faculty, given the necessary degree of competence, to better compete for N.R.C. and other grants. This pyramiding effect on support received for research was in part to insure that universities with ambitions for Ph.D. programs would and could provide a viable environment for these ambitions. Thus, the level of N.R.C. support received by a given department of chemistry is not only a measure of the competence of the individual staff members, but also a measure of the competence of the university in meeting its responsibilities to the aspirations of the department. For these reasons, the success of the faculty members in winning grants from N.R.C. is available information considered to be highly reliable to assess not only the individuals but also their departments and universities. This is particularly so since the members of the Grant Selection Committee for Chemistry chosen by N.R.C. were always carefully selected amongst the very best Canadian chemists and every committee possessed at least a substantial number of individuals with strong international reputations. Pressures naturally always existed for regional representation on the committee. However, a conscious effort was always made to cater to this pressure only when chemists considered to be of relevant proven stature could be found. Furthermore, especially in the past three years, the applicants were also rated by leading chemists from outside Canada. Thus, the rating of competence reflected by N.R.C. granting can reasonably be expected to reflect on a statistical basis the best world standards of performance by the partnership of the individual and his university.

N.R.C. has, to date, made so-called starter grants to new faculty and these were largely to newly-acquired assistant professors. Given an application from a new assistant professor, which reflected a reasonable degree of competence, starter grants of about $4,500 per year were made virtually automatically for the first three years of the appointment. For this reason, N.R.C. granting at the assistant professor level does not provide a measure of established competence. Furthermore, the large majority of the recipients do not have tenured positions. Therefore, the following assessment, based on N.R.C. granting, of the graduate programs of departments of chemistry in Ontario, will not consider grants at the assistant professorship level.

The N.R.C. grants for equipment, both minor and major, are expected and do bear some relation to competence. However, these, as well as computer grants, were to a large extent made on the basis of relative need as well as competence including some consideration of geographical factors. Thus, the amounts of these grants are not considered to reflect the relative worth of the Ph.D. programs to an acceptable degree of confidence and are not considered in this report except in reaching the tandem conclusions that the various departments are or are not adequately equipped for realistic engagement. The same applies to N.R.C. negotiated development grants which are granted to create centers of excellence and have no necessary relevance to existing competence. The funding received by individuals through negotiated development grants was not considered by the Grant Selection Committee in reaching decisions on the amounts awarded.

The consultants, of course, realize that the level of operating grant funding by N.R.C. is not an infallible yardstick for measuring the relative excellence of a man or a department. They are aware that some individuals receive substantial grants from sources other than N.R.C. However, their point is that the relative basis of comparison sought by them does not depend in their opinion on the total number of research dollars a man has at his disposal from various disaparate sources, but rather on the relative level of support accorded to him by a committee of his scientific peers evaluating his scientific contributions over a period of years against a large pool including the majority of his fellow scientists across the country judged by the same standards. For these reasons grants from sources other than N.R.C. are not included in Tables IV, V, VI, VII and X but the qualitative judgements in Table VIII while based to a large extent on the N.R.C. support levels have nevertheless been modified after discussion by the consultants on the basis of impressions gained in the course of site visits and of information from submitted data.

2. Analysis Based on N.R.C. Granting

(a) Departmental Competence

Table IV reports the average N.R.C. grant received by the professors and the associate professors in the departments of chemistry of the Ontario universities in the spring of 1972. In order to provide an external reference, the funding received at the University of Alberta is included since its department of chemistry is generally considered to conduct a Ph.D. program comparable in quality to the best in Canada. It is seen at once that Toronto, McMaster, Western Ontario and Ottawa received average grants in these two professorial ranks that are comparable and to a good approximation equivalent to that at Alberta. The grants made at Queen's, Guelph, Waterloo, Carleton and Windsor appear anomalously low for Ph.D. granting institutions with those at York clearly below Ottawa.

It is tacitly assumed that professors with an N.R.C. operating grant of $20,000 or more have demonstrated a high level of competence and are acknowledged

TABLE IV

Total and Average N.R.C. Operating Grants Received in 1972 by Professors and by Associate Professors in the Ten Ph.D. Granting Departments

UNIVERSITY	PROFESSORS		ASSOCIATE PROFESSORS	
	Total	Average	Total	Average
Carleton	94,700	11,838	26,500	4,416
Guelph	45,510	15,167	62,000	6,200
McMaster	307,000	23,616	86,500	8,650
Ottawa	119,000	19,833	47,000	9,400
Queen's	170,300	13,100	67,500	5,625
Toronto	356,500	23,766	107,000	8,917
Waterloo	101,300	11,256	62,000	4,769
Western	300,000	27,272	57,300	4,775
Windsor	66,000	9,450	13,500	3,380
York	122,500	17,500	19,500	2,440
For comparison:				
Alberta	439,000	24,389	99,080	10,500

leaders in their field. Toronto, McMaster, and Western have several leaders and Ottawa and York possess creditable numbers. In this regard, the impressive scientific strength in the Ottawa area as a consequence of the several government laboratories is an asset to Ottawa and Carleton which brings to these universities a scientific stature, through part-time appointments as sessional lecturers primarily to present graduate courses but also in research collaboration, not available to nearly the same degree at other Ontario universities. This matter is not, of course, reflected by the data presented in Table IV. The universities of Queen's, Guelph, Waterloo, Carleton and Windsor must at this time be considered deficient in the number of competent and capable faculty at the professorial level.

A consideration of the grants at the associate professorship level indicates that the universities of Toronto, McMaster and Ottawa have hired well and exercised strong tenure regulations since the majority of their faculty at this level qualify for important N.R.C. funding. The fact that 4 of 12 associate professors at Toronto received less than $5,000 is disconcerting. The majority (3) of these associate professors are attached to Toronto's suburban colleges (Erindale and Scarborough). Evidently, either the requirements for tenure or the opportunity provided at these satellite campuses for competitive engagement in research is inferior to those at the St. George campus. Efforts to ameliorate this situation are strongly recommended especially since the new campuses may aspire to graduate programs of their own as separated universities. The fact that 6 of 12 associate professors at Western and 6 of 9 at York received N.R.C. grants of less than $5,000 is also disturbing. York is expected to grow substantially in the next 10 years but this is not anticipated for Western Ontario. Thus, these figures do not augur well for the future of the Ph.D. programs in these now very good universities.

Efforts to redress these serious shortcomings are indicated and strongly recommended.

It must be pointed out that the N.R.C. granting data used in this report refers only to that faculty which received N.R.C. grants in the past five years. The reason for this decision was to eliminate faculty from consideration, especially in universities with relatively new graduate programs, which exists but for obvious reasons cannot be expected to contribute to the graduate work of the department. In the older graduate programs, the persons not included were normally individuals who had forsaken research activities to become full-time administrators. This was not always the case in new graduate programs, some were omitted who still participate in undergraduate teaching. Actually, this rather arbitrary decision did not materially affect the conclusions reached.

Taking into consideration the combined data of Tables IV and V and the general tenets of the above-mentioned hallmarks of a good department, the departments at Queen's, Guelph, Waterloo, Carleton and Windsor appear to be substandard with York as marginal. High standards for hiring and promotion seem best maintained at Ottawa. However, the breadith of competence and interests at this university with a total faculty of only 13 is too small (the recent reduction from 15 should be restored)*. A possible solution to this problem would be to cause an effective amalgamation of the Ph.D. programs of Ottawa and Carleton into a joint program. Together, these two departments would present a fine Ph.D. program.

Full professors who can achieve N.R.C. funding in the range $12,500 to $20,000, although not stars, must be considered important to the Ph.D. program of any university.

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* As implied in Table II

TABLE V

Distribution of the 1972 N.R.C. Operating Grants in Chemistry Among Professors and Associate Professors in Universities Granting Both M.Sc. and Ph.D. Degrees

UNIVERSITY	No. of Professors* With N.R.C. Grants in 1972				No. of Associate Professors* With N.R.C. Grants in 1972			
	Above $20,000	$12,500 - $20,000	$7,500 - $12,500	Below $ 7,500	Above $10,000	$7,500- $10,000	$5,000- $ 7,500	Below $ 5,000
Carleton	1	4	2	1	0	1	5	0
Guelph	0	3	0	0	2	2	3	3
McMaster	7	5	1	0	3	5	1	1
Ottawa	4	0	2	0	2	1	2	0
Queen's	2	3	4	4	4	0	2	6
Toronto	8	5	2	0	6	1	1	4
Waterloo	2	2	2	3	3	1	2	7
Western	7	3	1	0	1	2	3	6
Windsor	0	2	2	3	0	1	0	3
York	3	2	0	2	0	0	0	8
For comparison:								
Alberta	9	3	5	1	9	1	2	1

* Subject to the allowances made for individuals never or not now expected to be active in research.

Taking into consideration the long and excellent traditions for higher education at Queen's university, this institute should have a viable Ph.D. program. The necessary requirement in competence of faculty at the professorship level is not unduly alarming but concern must be expressed over the general promise of its group of associate professors. Upgrading in tenure requirements is indicated for Queen's to aspire to a long-term viability for its relatively new Ph.D. program.

York is impressive at its professorial level but with only 3 of its 9 associate professors with grants over $5,000, the Ph.D. program of this department appears to be in trouble. Fortunately, York, being situated in the metropolitan area of Toronto, has important growth potential. Important upgrading of its standards for tenure is indicated.

In conclusion, with regard to established departmental competence, only six of the ten Ontario universities with Ph.D. programs can be considered to qualify with three of these being marginal.

(b) Breadth of Research Interests

The classical fields of chemistry are inorganic, organic and physical chemistry. In relatively recent years, the analytical, biological and theoretical aspects of these disciplines have been identified and taken as legitimate fields for specialization. As seen from Table VI, these newer fields are attracting a rather small proportion of the total funding based on quality of performance, with theoretical chemistry receiving the most attention. Table VII shows how the money available was considered by the N.R.C. Grant Selection Committee best distributed amongst the established competence of the applicants regardless of field.

Assessment of the data given in Table VI (and collated in Table VII) together with other considerations (some partially intuitive) too numerous to enumerate, regarding the coverage of the fields of chemistry in the Ontario universities has led the consultants to the conclusions reached in Table VIII. On this basis, only Toronto and McMaster have acceptable strength across the fields of chemistry. The generally weak condition of analytical chemistry is not cause for concern unless a student wishes to specialize in the field. Four universities are strong in theoretical chemistry and these are of medium strength; on an individual basis the quality is very high. This situation is considered adequate since more strength in this rather specialized field does not seem warranted. However, the general strength in biological chemistry leaves much room for improvement. Especially in view of the very high degree of competence present in several centers in the fields of organic and inorganic chemistry, expertise which is of great consequence and need to biological chemistry, a deeper involvement is strongly called for. Special measures are recommended to remedy this situation since otherwise the departments of chemistry of the universities of Ontario can be expected to research themselves into oblivion.

Of major concern to this task is that the cut-off point deemed necessary for viable involvement in graduate studies (i.e., two A ratings in at least two fields in Table VIII, see Section III, A) seems to leave Guelph, Waterloo, Carleton and Windsor out of the picture. Admittedly all these centers are still in growing stages but the aspirations may prove to be unrealistic in terms of investment available for Ph.D. programs in chemistry in Ontario.

TABLE VI

Distribution of N.R.C. Operating Grants in Chemistry to Professors and Associate Professors According to Universities and Fields of Chemistry (1972)

FIELD			Organic	Physical	In-organic	Theo-retical	Analy-tical	Biolog-ical
1. Universities Offering Both M.Sc. and Ph.D. Degrees								
CARLETON:		A *	21,500	27,500	16,000	18,000	-	-
7,592	(14)†	B **	6,000	-	5,500	-	8,000	7,000
GUELPH:		A	29,500	16,000	-	-	-	-
8,962	(13)	B	12,625	25,550	13,025	2,900	-	10,900
McMASTER:		A	72,975	113,950	65,500	26,000	15,775	12,800
17,109	(23)	B	31,200	10,000	21,300	9,000	15,000	-
OTTAWA:		A	43,000	55,000	6,750	12,000	2,250	-
15,091	(11)	B	22,600	23,500	-	-	900	-
QUEEN'S:		A	78,300	50,500	-	14,000	8,800	15,200
9,792	(25)	B	12,800	38,500	12,800	3,000	4,500	6,400
TORONTO:		A	111,500	174,630	44,000	23,370	3,000	-
16,571	(27)	B	18,975	18,625	27,400	22,200	1,100+	18,700
WATERLOO:		A	4,000	79,500	10,100	-	8,000	8,500
9,942	(18)	B	26,500	14,500	11,000	10,350	6,500	-
WESTERN:		A	132,525	105,085	42,000	11,390	-	9,000
15,535	(23)	B	-	13,500	24,500	19,300	-	-
WINDSOR:		A	4,000	13,800	36,200	-	9,250	2,750
7,230	(11)	B	6,400	2,800	2,700	-	1,600	-
YORK:		A	13,500	70,500	12,000	20,000	-	4,500
9,470	(15)	B	9,400	6,500	3,000	2,000	-	600
2. Universities Offering M.Sc. Degrees Only								
BROCK:		A	17,500	2,500	-	-	-	-
7,300	(5)	B	1,600	9,300	5,600	-	-	-
LAKEHEAD:		A	-	24,000	-	-	-	-
6,429	(7)	B	7,000	5,000	9,000	-	-	-
LAURENTIAN:		A	-	-	-	-	-	-
		B	-	-	-	-	-	-
TRENT:		A	-	10,000	-	-	-	6,000
4,960	(5)	B	7,500	1,300	-	-	-	-

* A - Professors; ** B - Associate Professors

† Average per full-time staff member (number counted)

TABLE VII

Distribution of N.R.C. Operating Grants in Chemistry to Professors and Associate Professors in Ontario

Field	Amount Granted	Percentage of Total Granted
	$	%
Physical	912,040	38.7
Organic	690,900	29.4
Inorganic	368,375	15.7
Theoretical	193,510	8.2
Analytical	102,350	4.4
Biological	84,675	3.6
TOTAL	2,351,850	100.0

TABLE VIII

Assessment of Strengths* of the Ten Ph.D.-Granting Departments in the Fields of Chemistry Based Largely on National Research Council Grants, but Modified by Information Gained in Site Visits

University	Organic	Physical	Inorganic	Theoretical	Analytical	Biological
Carleton	B	B	B	B	B	C
Guelph	A	B	B	C		B
McMaster	A	A	A	A	A	B
Ottawa	A	A	C	B	C	
Queen's	A	A	C	B	A	B
Toronto	A	A	A	A	B	B
Waterloo	B	A	C	C	B	C
Western	A	A	A	A		C
Windsor	C	C	B		B	C
York	B	A	C	A		C

* A>B>C

(c) Viability and Potential for the Future

At this point, the assumption is made that the Ontario government may not be prepared to make further substantial investment for the expansion of graduate programs in chemistry. If so, it should take the opportunity of the present retrenchment to upgrade the existing situations. It seems unlikely that it will prove possible "to side-step the past mistakes by further increases in staff" (1).

Any consideration of data assembled in Table IX shows, that in the hurry to build undergraduate programs to meet the demands placed on universities by the sharp rise in population after the last war and help build a supply of Ph.D.'s to meet the shortage experienced in the early 1960's, there resulted an age distribution of the faculties skewed heavily to the younger side of a desirable distribution which would allow through regular retirement of faculty from research (normally either for reasons of age or administrative responsibilities) a continuing possibility to add young staff without an increase in the total number of faculty.

If nothing else emerged from this survey than to alert the chemistry departments of the Ontario universities to the problems of age distribution among staff, the expenditure should be worthwhile. As seen from Table IX, only a 15 year span in average age exists for about 90% of the tenured staff at Toronto, about 80% at Western, York and Ottawa, about 70% at McMaster, Queen's, Waterloo, Carleton and Guelph, and about 40% at Windsor. This faculty is in the 35 to 49 years of age bracket and, in theory, all could still be on staff another 15 to 30 years. In the absence of major expansion (which seems unlikely), there seems to be little scope for bringing in young

TABLE IX

Age Distributions for Professors (A) and Associate Professors (B) in Universities Offering Both M.Sc. and Ph.D. Degrees

			25-29	30-34	35-39	40-44	45-49	50-54	55-59	60+
Carleton	**A**	(8)	0	0	3	1	3	1	0	0
	B	(6)	1	1	3	0	0	1	0	0
Guelph	A	(4)	0	0	2	1	0	0	1	0
	B	(10)	0	5	4	1	0	0	0	0
McMaster	A	(13)	0	0	0	5	5	2	0	1
	B	(10)	0	2	7	1	0	0	0	0
Ottawa	A	(6)	0	0	1	2	2	0	1	0
	B	(5)	0	1	2	2	0	0	0	0
Queen's	A	(13)	0	0	1	2	4	2	3	1
	B	(12)	0	11	1	0	0	0	0	0
Toronto	A	(15)	0	0	0	6	6	1	2	0
	B	(13)	0	0	8	4	1	0	0	0
Waterloo	A	(11)	0	0	2	2	3	2	1	1
	B	(16)	0	4	2	6	1	3	0	0
Western	A	(11)	0	0	4	4	2	1	0	0
	B	(12)	0	3	5	2	1	0	1	0
Windsor	A	(7)	0	0	1	4	1	1	0	0
	B	(4)	0	0	4	0	0	0	0	0
York	A	(7)	0	0	0	2	4	0	0	1
	B	(9)	0	2	7	0	0	0	0	0

TABLE X

The number of faculty (in brackets) considered of direct importance to the Ph.D. program in age groups with the total amount of N.R.C. funding (in $) within each group in 1972 for Professors (A) and Associate Professors (B)

UNIVERSITY		AGE GROUP IN YEARS							
		25 - 29	30 - 34	35 - 39	40 - 44	45 - 49	50 - 54	55 - 59	60 +
			$	$	$	$	$	$	$
Carleton	A	0	0	55,500 (3)	11,000 (1)	12,500 (2)	0	0	0
	B	0	6,000 (1)	7,000 (1)	0	0	8,000 (1)	0	0
Guelph	A	0	0	31,500 (2)	14,000 (1)				
	B	0	35,000 (5)	15,000 (2)	12,000 (1)				
McMaster	A	0	0	0	93,000 (5)	137,000 (5)	47,000 (2)	0	30,000 (1)
	B		11,000 (2)	66,500 (7)	9,000 (1)	0	0	0	0
Ottawa	A	0	0	12,000 (1)	29,000 (2)	53,000 (2)	0	25,000 (1)	0
	B	0	12,500 (1)	11,000 (2)	23,500 (2)	0	0	0	0
Queen's	A	0	0	10,500 (1)	44,500 (2)	35,500 (4)	19,200 (2)	22,600 (2)	38,000 (1)
	B	0	0	67,500 (8)	0	0	0	0	0
Toronto	A	0	0	0	161,000 (6)	140,000 (6)	19,000 (1)	36,000 (2)	0
	B	0	0	68,500 (8)	39,500 (4)	0	0	0	0
Waterloo	A	0	0	14,000 (1)	38,000 (2)	24,500 (3)	22,000 (1)	8,000 (1)	4,000 (1)
	B	0	34,850 (4)	12,000 (1)	19,000 (3)	0	3,000 (1)	0	0
Western	A	0	0	68,500 (4)	111,500 (4)	90,000 (2)	30,000 (1)	0	0
	B	0	22,300 (3)	21,500 (2)	6,000 (1)	3,000 (1)	4,500 (1)	0	0
Windsor	A	0	0	14,500 (1)	41,000 (4)	4,000 (1)	6,500 (1)	0	0
	B	0	0	13,500 (4)	0	0	0	0	0
York	A	0	0	0	46,000 (2)	54,413 (9)	0	0	0
	B	0	6,000 (1)	29,500 (4)	0	0	0	0	0
TOTAL	A			206,500	588,500	550,913	143,700	91,600	72,000
TOTAL	B		127,650	312,000	109,000	3,000	15,500		

people as tenured staff into the departments over the next 15 years. In 1982 roughly 75% of the staff of the major departments will have taken their Ph.D.'s in the 1950's. This situation cannot be entertained lightly and opportunities for correction should be kept foremost in future employment policies. Since most leading universities have this problem, it is unlikely that the problem will be ameliorated substantially by people in this age group moving out of the province.

Table X shows how the 1972 grants from N.R.C. are distributed amongst the various age groups. Of particular concern is that these amounts are expected to reflect competence and 50% of the total amount granted in Ontario is in the 40 to 49 years of age group and the recipients represent about 40% of all the faculty.

VI. General Comments

A. Facilities

The facilities for graduate research found in the 10 Ph.D. granting departments were from good to very good. There were no complaints about library needs except at the smaller campuses and their handicap was not well met by the inter-library loan system. Although the real costs for graduate research are considered to be well represented in Table III, it must be kept in mind that the initial investment for plant facilities is now near complete and little further expansion is required to house all the research facilities required in Ontario chemistry departments for the foreseeable future. Some of these facilities could be much more effectively located. For example, Ottawa maintains one of the stronger centers for graduate study in chemistry but does so under overly crowded conditions and is in need of additional plant. On the other hand, departments of lesser stature have underemployed laboratories. Except for such anomalies, the departments can be expected to operate efficiently without further substantial capital investment for buildings. However, investment in major equipment will be a continuing need--chemistry marches on! In most cases, the cost of graduate research at the present level can be expected to be near operational costs for the foreseeable future.

B. Operational Costs

As seen from Table III, it is estimated that the net cost for the conduct of graduate studies and research in chemistry in Ontario is about $7.0 million per year, superimposed on an undergraduate instructional cost of $10.2 million. For this expenditure, Ontario has purchased one of the world's superior systems of higher education in chemistry. By cutting out all research activity the cost of the undergraduate training in chemistry would be reduced to about $10.2 million but the product would be predictably (with complete certainty) not merely inferior but inadequate with steadily declining standards. One should take note at this time that the knowledge of chemistry is basic to modern society and is not one of the gimmicks of the many modern educational ventures. It is indeed expected that more and more it will become realized that a sound grasp of chemistry is basic to proper education since chemistry and its application not only touches but often dominates many areas of human need, such as health, food, shelter, clothing, energy, transportation, pollution control and the materials needed for the arts, pleasure and sport. The fact that, in this time of declining undergraduate enrollment, registration in chemistry courses continues to rise documents the central importance of chemical education.

The consultants have been informed that the Ontario chemistry department research budgets have already suffered cuts. To cut them further by even only 10% would have an immediate undesirable adverse effect on the standards not only of graduate but also of undergraduate studies in chemistry. The saving would be about $700,000 per year or less than 10¢ per citizen of Ontario per year. Surely, any talk of further cuts is unwarranted and must not be done. Instead, consideration should be given to ways and means of increasing the budget if this is at all possible involving, if necessary, the redirection of educational funds. Should the estimates made in Table III be nearly correct, Ontario is spending less per capita than some other Canadian provinces. Ontario has an important responsibility to all of Canada. Its population is more than a third of the country and it is the most affluent part of Canada. Furthermore, Ontario is the heartland of Canadian secondary industry, the activities of which are largely the product of chemically based innovations either directly or indirectly. It behooves the Ontario government to keep Ontario chemistry strong and this can only be accomplished by strength in its programs for graduate study and research.

Quality must always take precedence over quantity and quality cannot be achieved with undue dilution. These considerations are the main thrust behind the recommendations made in this report to the Advisory Committee on Academic Planning for the Council of Ontario Universities. Let there be more concentration on how better to spend the dollars and not on how many fewer dollars may be spent.

C. Admissions

A good Ph.D. granting department should be able, indeed should be required, to attract good graduate students from other good universities. If the department and its staff members do not have reputations such as to attract fine graduate students from other universities the right to give the Ph.D. degree should be questioned.

It is recognized that a single university cannot be expected to forego the right to keep its own undergraduates as this might lead merely to sending better students away than it would receive in return. Students should shift research supervisors between the B.Sc. and M.Sc. and again between M.Sc. and Ph.D. Postdoctoral years should invariably be spent in other institutions. There is already a trend in Ontario, as in many other Canadian universities, for students to remain at the same university for both the B.Sc. and Ph.D. degrees. This line of least resistance is academically unsound both for the student and the department. The training of the student is liable to be unduly narrow and the staff member may have graduate students beyond what he deserves. This problem can be expected to become more acute with increasing competition between Ontario departments to maintain graduate student populations above the minimum level for a viable Ph.D. program. The consultants are impressed with the efforts of the Discipline Committee for chemistry and recommend that it should continue to function. This group should maintain vigilance on matters such as the numbers of students staying on for the Ph.D. degree at the university which granted the B.Sc. degree. Furthermore, in view of the prevailing circumstances, perhaps consideration should be given to establishing a common placement examination for the Ontario graduate students of chemistry.

Admission of new graduate students is traditionally based on academic records, on letters of recommendation and on the adequacy of training as judged by courses and examinations taken. Unless the departments are well acquainted with the applicant's university training, academic records can be very misleading. Letters of recommendation mean little unless the reputations as letter writers of the staff members writing the letters are known. The entrance requirement of a B^+ average has undoubtedly eliminated some misfits who would not belong in a graduate school. However, the history of science is replete with cases which show that grades in courses and examinations do not necessarily measure well those intangibles which make a person a great research worker. Therefore, it is recommended that a B average not necessarily disqualify a student from graduate studies in Ontario, especially if the student is a Canadian and a more thorough examination of his potential as a researcher (in contrast to book learner) is relatively easy to achieve.

There are several very fine universities in Ontario and such universities should atract and admit properly qualified graduate students from any country in the world and thereby play the role on the world scene to which they are entitled. Present regulations governing N.R.C. scholarships and grants and Ontario graduate fellowships preclude support of graduate students who are not citizens or landed immigrants. While the consultants hope that action on a national scale might be undertaken to reintroduce support for a small percentage of particularly gifted students from abroad, they would urge the administrators both of the Ontario graduate fellowship program and of the graduate student scholarship arrangements in individual universities to take action on a provincial or local level to assure a reasonable admixture of foreign trained students in their graduate school populations.

The matter of fees charged graduate students came to the consultants in the form of often bitter comments by graduate students. It would be most unwise for the universities of Ontario to provide lower net incomes to graduate teaching assistants than are provided by other Canadian universities.

However, in the last analysis, graduate programs will generally attract their just deserts and a relative decline in applications from acceptable students should in the first instance cause concern over the image cast in the academic world by the department so involved. The basic question to answer is, does the department project an image of being an intellectually exciting and relevant place to do graduate work. Judging from student comments some of the departments visited should ask this question now.

D. Relations with Industry

Except possibly for some faculty members at Toronto and Trent there is virtually no continuing relationship between staff members of the departments visited and industry. Anyone who understands the nature of Canada's chemical industry cannot be surprised about this deplorable situation. However, one must worry about the effect of such isolation on higher education since it must inevitably adversely affect such matters as course content, the degree of relevance for the basic research programs chosen, student counselling and the realism of attitudes toward industry and its requirements especially as to the quality of Ph.D.'s meaningful to industry. This problem cannot be solved by the professors themselves but, hopefully, a Canadian industrial base will soon emerge to solve this pernicious problem.

VII. Recommendations

1. It is recommended that no attempt be made to forecast the need for recipients of the degree of Ph.D. in chemistry. On the other hand, the level of expenditure for the support of graduate studies and research in Ontario is not considered high and it is recommended that any saving resulting from declining enrollments be employed to improve the standards in staff and facilities especially in presently viable but newer Ph.D. granting departments.

(See Sections III.A and V.A)

2. The consultants express their hope that the faculties and administrations of Ontario universities, individual students both currently enrolled in and considering embarking on a graduate program in chemistry, and also society at large as represented by bodies allocating financial resources, will not over-react to a seeming temporary mismatch between the number of students currently seeking and obtaining Ph.D. degrees in chemistry and the openings available to them. The over-reaction to be avoided is a precipitous reduction in the total graduate student enrollment in chemistry in Ontario either imposed externally or resulting from voluntary institutional or individual action. At the same time the desirability of maintaining and improving the overall quality of Ph.D. programs by concentrating them in a smaller number of universities should be seriously examined.

(See Sections IIA., II.B, V.A and VI.B)

3. It is recommended that a minimum staff of fifteen full-time faculty members of the rank of assistant professor or above, and a graduate student enrollment somewhat in excess of thirty be recognized as minimum conditions for a department to be accredited as being competent to offer the Ph.D. degree in chemistry. The following ancillary requirements should also be met:

(a) Strength in at least one of three traditional branches of chemistry (inorganic, organic and physical), strength in a second branch selected from an augmented list containing analytical, biochemical and theoretical branches in addition to the traditional three, and competence in at least one more branch from this augmented list.

(b) Sufficient eminence of faculty to attract able graduate students.

(c) Related departments (e.g. mathematics, physics) should be competent to provide the necessary auxilary training.

(d) The presence of several postdoctoral fellows is highly desirable.

(e) The undergraduate base should be not far below 1800 full courses in chemistry per year.

(See Sections III.A and V.B.1)

4a. The facilities and staff, including potential for development, presently available in the ten departments currently offering Ph.D. programs in chemistry in Ontario can provide between 80 and 150 Ph.D.'s per year. It is recommended that the number of departments authorized to grant Ph.D. degrees in chemistry not be increased above the present ten (namely: Carleton, Guelph, McMaster, Ottawa, Queen's, Toronto, Waterloo, Western, Windsor and York), but that the viability of these programs be reexamined in 1978 with respect to the criteria in recommendation 3 above, and that departments be notified in 1973 that wherever these minimum requirements are not met by a wide margin by 1978 the authorization to accept further students into Ph.D. programs will be withdrawn, and any borderline cases will be closely scrutinized with the same aim in view. Those departments which in the light of local conditions do not foresee a possibility of attaining these minimum requirements by 1978 should be encouraged to start a voluntary phasing out of their Ph.D. programs now to achieve a smooth transition.

(See Section V.B.2)

4b. It is recommended that the four universities of Ontario which at present offer work leading to the M.Sc. but not the Ph.D. degree in chemistry (Brock, Lakehead, Laurentian and Trent) not be authorized to introduce Ph.D. programs at present since enough good graduate students are not seeking entry into the field of chemistry to form additional viable Ph.D. programs. This matter should be reviewed from time to time but not before 1978. Should Scarborough or Erindale become independent instituions, or should other new institutions emerge, they should not be authorized to embark on an independent Ph.D. program until a further review indicates this to be justified.

(See Sections V.A, V.B.2b)

5. It is recommended that provision should be made to facilitate active involvement in research work (through provision of postdoctoral fellows, technicians, or special leave) for faculty members of those departments that are not authorized to offer Ph.D. programs and thus lack graduate students at the Ph.D. level as auxiliary research manpower.

(See Sections III.C and IV.B.2)

6. Departments, particularly those in close geographical proximity, are urged to intensify, through close consultation, their present efforts to share equipment, to introduce joint programs, to build complementary areas of strength, and to avoid duplication.

(See Sections V.B and VI.A)

7a. Especially with regard to the urgent need for monitoring of the environment with respect to effects of pollution on ecological systems, it is recommended that the field of analytical chemistry be reinforced in some departments in Ontario universities and that concern be shown for the implementation of the results of such activity. Strengthening of analytical chemistry in the general areas of clinical and forensic chemistry also deserves increased attention. These areas, together with the general area of pollution monitoring and control, represent the main areas for preoccupation with application oriented research suitable for Ph.D. programs. As the development of methods must be based on physics, availability of cooperation with a good physics department will be needed.

7b. Biological phenomena at the molecular level will best be examined under conditions when the research is performed within the competence of departments of chemistry, and it is strongly recommended, especially in view of the generally low level of such activity in Ontario departments of chemistry, that these departments show increased awareness for meaningful chemical research at the frontiers of investigations into biological systems. The consultants believe that in general forward looking work in biochemistry will be done in chemistry departments rather than in medical schools, but existing patterns may at times be difficult to change.

(See Section V.B.2b)

8. Meaningful application oriented research must be carried out in close contact with market requirements, cost analyses and patent action and, as a consequence, must always be subject to continuing appraisal as to possible abandonment. Being, in general, a very costly variety of research which, when not successful, is normally of no or only marginal importance either in improving human knowledge or human welfare, it is recommended that great care be exercised prior to the admission of applied research into universities where it could prove excessively expensive while seriously hindering communication between scholars and very difficult to curtail at an appropriate time. Applied research should be distinguished from mission oriented research of a basic variety.

(See Section VI.D)

9. Although considerable care is now exercised in the promotion of faculty to the rank of professor, more attention should be paid to the promotion of faculty to tenure positions. It is extremely important that only the very best faculty members receive tenure, and it is recommended that positive action in this direction be required from all the departments with due consideration for age distribution amongst the permanent staff.

(See Sections III.B and V.B.2c)

10. Departments approved to offer Ph.D. programs should evolve, both for academic and financial reasons, departmental, faculty or university-wide procedures for evaluating qualifications of individual faculty members as potential supervisors of Ph.D. thesis projects.

(See Section III.B)

11. Students will generally receive a more broadening educational experience, both personally and scholastically, if they do their graduate work at some university other than where they obtained their undergraduate degree. The departments are urged to avoid trying to keep their own graduates but should advise them to go elsewhere for their graduate studies.

(See Section VI.C)

12. It is recommended that some funds should be made available for support in Ontario universities of a small percentage of able, well-qualified graduate students from abroad who at present, for reasons of citizenship or immigration status, can not receive financial aid from funds provided by N.R.C. and some other granting agencies.

(See Section VI.C)

13. The consultants wish to compliment the "Discipline Group" in chemistry on its activities to date and recommend the continuation of regular meetings of the "Discipline Group," and, in particular, the sharing of information on graduate admissions and on mechanisms for maintenance of standards.

(See Section VI.C)

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APPENDIX B

DISCIPLINE GROUP RESPONSE

BEST COPY AVAILABLE

Members of the Chemistry Discipline Group met to discuss the draft report of the consultants on February 16, and met with the consultants the following day. They met again to discuss the consultants' final report on April 13, 1973. This report attempts to summarize the views expressed at this second meeting. These views take the form of general comments concerning the whole consultants' report, and then specific responses to the thirteen recommendations therein. It would be unrealistic to expect that members of the discipline group would adopt uniform or unanimous attitudes to all of the comments and recommendations expressed by the consultants. On the other hand there was much that the discipline group could find to agree upon, and this report will express those sentiments that appeared to secure broad support. It was evident that with respect to some matters the group could not find a common viewpoint, and it was taken for granted that where this occurred the various, and perhaps even contradictory, opinions of the individual departments would find expression through the submissions of their respective universities.

Quo Vadis ?

Throughout the meeting of April 13 there was a recurrent theme in the discussions of the discipline group which might best be described as a widespread uneasiness over where this particular discipline planning assessment was heading. To be more specific, concern was expressed over what appeared to be discrepancies in the description of the purpose and method of "discipline planning assessments" as given in the recently published brochure "Stimulus and Response", and the amount and kind of relationship to these objectives that was evident in the comments and recommendations of the consultants. The consultants, for instance, have balked at their first charge, viz.- to comment on manpower needs and desirable enrolments for graduate study in different areas of chemistry. We are not so naive as to think this would be easy, but we believe that some ranges of numbers could have been arrived at as a basis for systems planning. No such estimates are given, and one may infer from the consultants' report that the sorts of controls presently exercised, and initiated voluntarily by the Committee of Chemistry Department Chairmen of the Ontario Universities before this planning assessment was even thought of, are judged to be appropriate. These controls, which prominently emphasize higher academic quality, have in the course of three consecutive years ensured that academic standards in graduate work have been maintained. They have resulted, when operated simultaneously with a slump in the job-market, in a significant reduction in the graduate student population in chemistry in the Ontario universities. It is ironic that outside Ontario, where no control mechanisms are in force, the numbers of graduate students in chemistry admitted in 1972-73 was greater than in the previous year.

Some Questions Related to Costs

The consultants have structured a financial model to arrive at estimates of the costs of educating Ph.D. students and M.Sc. students per annum. These estimates appear to show that the present costs of the graduate programs in chemistry in the Ontario universities are not high, and do not appear to differ greatly from institution to institution. Their model assumes that a certain population of graduate students is necessary at each university to carry out part-time teaching duties. Since many Ph.D.'s trained in chemistry aspire to educational employment, this training in teaching is an important complement to the professional education. It is our view that the consultants' estimates of numbers of G.T.A.'s required according to their model (Table II) may be low by about 50% on the basis of rates of pay and hours of work for this service presently specified under Ontario MCU regulations. Table II indicates that the number of graduate students required as teaching assistants is roughly 2/3 of the present number. If the estimate is increased by 50% on the basis just given, would appear that the present population of graduate students bears just about the right relationship to the present undergraduate base. Members of the discipline group affirm their belief in the need for teaching assistance at a level no less than at present, in view of the significant amount of time devoted to practical instruction in the laboratory.

One of the consultants' recommendations is that consideration be given to concentrating Ph.D. programs in a smaller number of universities. The implied advantage of this move is that programs of higher quality could be offered in a limited number of departments. It may be appropriate to point out certain aspects of costing that would be consequences of this recommendation. First of all, if the total number of graduate students in the Ontario system is to remain unchanged, there would be no reduction in cost, since the consultants have estimated the cost per Ph.D. student to be roughly the same in the various departments. Secondly, to maintain present undergraduate student levels in departments from which Ph.D. students are withdrawn would entail an added operating cost to provide auxiliary teaching personnel. Thirdly, concerning a point on which the consultants have made no comment, consolidation of research in at least some areas might ease pressure on capital financing required for expensive items of major equipment.

The Quest for Excellence

At a time when it is not uncommon to read and hear pejorative statements about academic standards, and when many students in our universities have displayed a remarkable indifference to the pursuit of excellence, it is refreshing and commendable to encounter the clear, uncompromising viewpoint of the consultants on the subject of quality in our graduate programs. We hope their remarks will not go unnoticed by students or faculty members in our institutions, nor by the general public who may at times not fully appreciate the peculiar aspirations of scholarship.

In their stress upon the need for excellence the consultants may unwittingly have created some unfavourable impressions concerning the calibre of the Ontario chemistry departments. There are oblique allusions to the quality of junior appointées, to the improper award of tenure, and statements to the effect that certain departments appear to be substandard. In evaluating such remarks the reader ought to keep in mind that, as regards research and graduate work chemistry is a relatively long-established and intensely competitive discipline. The standards of performance imposed by the referees in chemical journals or by the selection committees in award-granting institutions are extremely demanding. Academic chemists take these requirements for granted: we hope that academics in other areas will appreciate the climate of competition in which we work, and will not misinterpret the consultants' comments regarding excellence as indicative of inadequate performance within the Ontario chemistry departments.

In accordance with their terms of reference, the consultants undertook an evaluation of the quality of the graduate work in six areas of chemistry within the fourteen Ontario departments. They have presented their evidence based almost exclusively on the value of the annual operating grants awarded to faculty members through the Awards Program of the National Research Council of Canada. Their analysis is summarized in Table VIII of their report. They have intimated that other unspecified (and unspecifiable) considerations, in addition to N.R.C. operating grants have gone into the assessment embodied in Table VIII. It would have made considerably easier the task of those required to act upon or respond to this aspect of the consultants' report if these other considerations could have been described more clearly.

Within the discipline group there was a good deal of concern over the manner in which this part of the assessment was handled by the consultants. It is clear and requires no further comment that three or four departments of chemistry in Ontario are large and strong, both from the standpoint of prestige of faculty members (measured by NRC grants or any other way), and on the basis of enrolments of Ph.D. students, numbers of postdoctoral fellows, and so forth. In these well-established prestigious departments the future of Ph.D. studies is assured.

There are six or seven other departments where Ph.D. programs are in operation but for one reason or another the situation is less clear-cut. It is in respect of the assessment of these that members of the discipline group found substantial cause for concern. If the consultants' recommendations are taken at face value, no immediate action with respect to the programs of this group of departments is required. But if the discipline assessment is seen as provoking more imminent response, it is felt that a more thorough and more substantiated evaluation of these middle-range departments is required before action can be taken. The group feels that while N.R.C. grants provide an unexceptionable criterion for singling out the three or four best departments in the province, they are not a sufficiently discriminating measure to permit meaningful differentiation to be made within either the first or the second group.

The consultants have alluded in their report to information gained from site visits to each department, and implied that this has influenced their assessments. Members of the discipline group are compelled to register their disappointment at how little evidence appears in the report to suggest that site visits even took place, much less were of any value. In fairness to the consultants it must be acknowledged that the duration and spacing of the visitations to the fourteen departments militated against their effectiveness for purposes of gathering sufficient information on which a precise assessment could be based.

Returning to the evidence of Tables V to VIII, some concern is felt that the comparisons of departments reflect too heavily the amounts of NRC annual operating grants. It is understandable that the consultants find these a reliable and convenient parameter for the measurements of research accomplishment. But, as the data of Table VII in their report show, the N.R.C. grants do not support all areas of chemistry to the same degree, nor indeed are these areas equal to one another in importance. Special computing grants awarded also by N.R.C. in open competition were not included in the consultants' analysis. The grant-earning capability of a department is subject to change, and it would be unfortunate if 1972 awards, because of being included in this report, came to obscure the efforts of departments to improve their performance.

One last comment on the quality assessments made by the consultants: while specifically not requested in their terms of reference, the authors of this report might have helped their readers to gain an impression of the relative effectiveness of the chemistry graduate programs in Ontario by providing some reference data from outside the province. It is true they have cited comparative figures from Edmonton, one of the most powerful departments in the country. But it is clearly pointless to expect institutions like York or Carleton to match the performance of Edmonton - a comparison with Calgary, for instance, would in these cases be more meaningful. The discipline group requested this in February, but we must infer that suitable data could not be secured in time.

Some Other General Comments

We commend the consultants for stating clearly the dangers inherent in short-term reactions to what appear to be mismatches in the supply of and demand for highly specialized manpower. The period 1970-72 saw a slump in employment possibilities for Ph.D. chemists which seemed to create some anxieties in both academic and political circles. These conditions in the marketplace have quite quickly resulted in reductions in the numbers of applicants for graduate study. By 1973, the collective and practically unanimous view of members of the discipline group is that the employment prospects for graduates in chemistry have strengthened. Since many Ph.D. graduates in 1973 would have begun graduate work in 1969-70, the period of this perturbation in the job market may be of the same magnitude as the time required to produce a doctoral graduate. We affirm, therefore, the consultants' warnings about institutional or government action to manipulate the flow of graduate students in response to short-term imbalances in supply and demand for manpower at this level.

We are pleased that the consultants have publicly reaffirmed the importance of establishing and maintaining a proper research environment in a teaching department. The attitudes to chemistry (or any other discipline) that require to be imparted to undergraduates are much better conveyed by men (or women) whose experience includes day-to-day handling of real problems. Research, done or directed by faculty members, and the publication of this in international journals remains, notwithstanding a certain amount of prevailing cant, the only guarantee of relevant and inspiring scholarship.

There are one or two allusions in the consultants' report to which we are compelled to take exception. In a report of this sort it seems unfortunate that the role of graduate students in chemistry is described in such terms as suggested by the following quotations:

> "the main purpose of Ph.D. programs is to attract bright young people to become engaged in research with staff members and thereby help keep the staff professionally alive." (p.A-10)
>
> "departments that are not authorized to offer Ph.D. programs and thus lack graduate students at the Ph.D. level as auxiliary research manpower." (p.A-58)

Responses to the Thirteen Recommendations

1. We are not sure that the stated purposes of this discipline planning assessment can be altogether met in the absence of any quantitative evidence or estimates of manpower requirements. We have previously suggested that the consultants have provided at least one numerical basis for planning a graduate student population, and that is the number required to provide auxiliary teaching service. Our view is that this number is no less than the present graduate enrolment in Ontario. If the number of graduate students falls below this level while the present undergraduate base stays constant, the need for auxiliary teaching will remain and will have to be financed in some other way.

   The discipline group also endorses the suggestion that any savings (presumably to the government) through declining enrolments should be made available to the universities. We are inclined to think that any such financial concessions would no more than permit the present level of quality in chemistry education to be maintained. Owing to difficulties found within the group in interpreting the last line and a half of this section, we would not be prepared to accept at this stage the notion of discriminatory financial assistance.

2. We have already indicated our approval of the sentiments in this recommendation, with the exception of the last sentence. Implementation of the last suggestion would require considerable further study and cost analysis within each affected university.

3. The discipline group acknowledges that the criteria listed in this section represent one way of defining the viability of a Ph.D. program. We would like to stress, however, that there are alternatives, and a rigid insistence on some of these parameters would be regarded as inappropriate in many other jurisdictions outside North America.

   To select one specific matter for discussion, it is suggested that a minimum number of graduate students should be required, presumably to achieve a research atmosphere with plenty of personal interactions. Could it not be asked whether the same extent and value of interaction would be achieved with a smaller number of graduate students and an appreciable number of postdoctoral fellows?

   See also a comment under 4(a).

4. (a) The discipline group notes that the consultants' report advocates the continuation of all existing Ph.D. programs for the next five years. This period provides some opportunity for departments to make good any serious deficiencies that may have been indicated by this report, and to give time for enrolments to stabilize. We feel that this recommendation is fair and appropriate. It is extremely important, however, that all departments agree to and maintain high ethical standards in recruitment of graduate students during this period.

   We are unanimous in our belief that should the viability of any of these ten programs be questioned in 1978, or earlier if necessary, the proper procedure would be to initiate a properly constituted appraisal procedure for that program. Our previous comments should make it clear that we are not satisfied that the examination made in this assessment is sufficient for any action being taken to affect the operation of a particular department.

   A statement from one of our members which found general support was that recommendations 3 and 4(a) were only acceptable if the consultants' criteria (#3) were regarded as an indication of which programs and departments should be submitted to formal appraisal at the appropriate time (4(a)).

   (b) This recommendation appears sensible. It might be preferable if the wording in line 5 of #4(a) be amended to include the word "now" before the verb "be increased".

5. The discipline group favours the principle of this recommendation, though is puzzled by how it can be achieved financially. One proposal that has earlier been put forward from the Committee of Chemistry Department Chairmen of the Ontario Universities is that provision be established for the funding of some post-doctoral fellows through B.I.U. The mechanism suggested was that one post-doctoral fellow be financed for each $40,000 in research grants awarded in open compe-

tition. The details of the original proposal provided modifications to benefit the developing university departments. (See letter H.C. Clark to J.B. Macdonald, Executive Vice-Chairman, Committee of Presidents, April 14, 1970; also to D.C. Williams, Chairman, Committee of Presidents, March 2, 1971).

The group is of the opinion that recommendation 5 is that which would make possible the implementation of #4, especially in cases of terminating existing Ph.D. programs. The implementation of phasing out present Ph.D. programs without compensatory introduction of #5 would create considerable hardship and be destructive to faculty morale.

6. This recommendation is already being implemented in various ways.

7. The group recognizes that biological chemistry occupies a somewhat different status from the other named areas. Biochemistry in a number of universities is in a separate department, often in a different faculty. In the circumstances there are problems in identifying and surveying activity in this field. There are also difficulties experienced in securing funding for research in non-medical biochemistry, which have inhibited development in some cases.

8. No comment.

9. We are aware that there is a problem here which perhaps especially has grown up in the newer universities. It is not unique to chemistry or to Ontario.

10. Certain of our member universities have procedures of the sort described. It is intended to examine this practice in more detail.

11. This recommendation is worthwhile. Members of the group have agreed to exchange information on graduating students annually, and will examine other wavs of encouraging this practice.

12. This recommendation is strongly endorsed; the group finds present restrictions odious, and would prefer to have the authority to make discretionary awards to a limited number of highly qualified non-resident students.

13. Amen.

UNIVERSITY OF TORONTO
DEPARTMENT OF CHEMISTRY

LASH MILLER CHEMICAL LABORATORIES
80 ST. GEORGE ST TORONTO CANADA
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OFFICE OF THE CHAIRMAN

MAY - 3 1973

May 1, 1973.

Advisory Committee on Academic Planning,
102 Bloor Street West,
Toronto, Ontario.

c/o Dr. M.A. Preston

Gentlemen:

I wish to dissent from part of the Report of the Discipline Group on the ACAP consultants' report on Chemistry.

My objection is to parts of paragraphs on p. 2, especially that which begins "One of the consultants" and ends "major equipment". I requested deletion of this entire paragraph from the Draft version of the report which I had seen. Instead, it has been rewritten, admittedly in part to answer my original objections, but I cannot accept the implications of the paragraph as rewritten either.

The paragraph implies that the Discipline Group has accepted (presumably after consideration) the mathematical model of a Chemistry Department, and its cost findings as outlined by the Consultants in their Report, since the Group uses the findings to make arguments about costs. In fact, I do not consider that the Discipline Group did carefully consider this model (it really wasn't made much use of in the Consultants' report), and, in my opinion, the model is totally erroneous in its conclusions that the cost of a Ph.D. program is about the same regardless of the size of a Department. To suggest that costs of graduate training (or anything else) will be about the same regardless of the size of the operation, is contrary to all basic experience in production costs.

The Consultants' model shows that graduate costs per student decrease slightly as the number of graduate students changes from twice the number of Graduate Teaching Assistants needed for undergraduate use to three times the number of

Graduate Teaching Assistants needed for undergraduate use (Table I). At the same time, the cost per undergraduate course significantly increases with larger numbers of graduate students. What the consultants did not point out, nor the Discipline Group recognize, accepting momentarily the validity of the model, is, that as the number of graduate students drops, the cost for graduate instruction increases markedly, and the costs per undergraduate course diminish.

For example, for a Department of 1800 courses, 31 classes, and the equivalent of 7.5 sessional lecturers ≡ 30 Graduate Teaching Assistants

No. of graduate students	Cost per graduate student	Cost per undergraduate course
90	12,100	628
60	12,480	539
50	12,580	495
40	12,825	459
30	13,233	424*
20	15,300	388*
0	0	318*

*Sessional lectures would (might - for 30 graduates) be involved here, at no cost to undergraduate teaching but at an increased total cost, thereby increasing apparent graduate costs.

This is an interesting finding, which certainly negates the comments in the Discipline Group's Report, about costs of graduate instruction, and a situation which is increasingly pertinent as the number of graduate students steadily falls in most Ontario Departments.

Turning to a more careful analysis of the model, examination of the bases of the calculations indicate that all the costs considered by the Consultants (staff, Graduate Teaching Assistants, graduate students (and which cover overhead)) are linear functions of the number of undergraduate student courses (or number of classes).

For the graduate part of the cost analysis, such assumptions are ludicrous. There are obviously very significant fixed costs of the physical plant and much (but not all) of its heating and lighting that remain constant regardless of whether one or n graduate students are in the Department. Similarly, there are fixed costs for some major equipment (eg. machine shops, spectrometers, etc.) and technical personnel, etc. where the costs are essentially the same, regardless of whether one or n students are involved, although these costs may be step-functions, since with n + 1 students it may be necessary to purchase a second lathe or spectrometer. At the same time, there obviously are many costs which do vary directly with the numbers of students (supplies, minor common equipment, part of costs of services and utilities, etc.), which are built into the Consultants' model. Having ignored the former kind of fixed costs, it is not surprizing that it was found that there was little effect of size of a graduate department on the costs of graduate instruction.

I therefore wish to point out that the findings from the mathematical model cannot be employed to get any reliable measure of costs of graduate instruction, and I submit

(a) that there would be significant additional costs, if a Department operates a graduate program with an inefficiently small number of graduate students.

(b) that in general the employment of sessional lecturers, in lieu of graduate students in the Graduate Teaching Assistant function, is a cost saving, and not an added operating cost, contrary to the statement in the Discipline Group's Report on P.2.

Yours sincerely,

A G Brook

A.G. Brook,
Professor and Chairman.

AGB/ew

c.c. Discipline Group

APPENDIX C

BEST COPY AVAILABLE

UNIVERSITY COMMENTS

Comments appear from Brock, Carleton, Guelph, Lakehead, McMaster, Ottawa, Queen's, Toronto, Trent, Waterloo, Western Ontario, Windsor and York.

University Comments on Consultants' Report

Our major concern with the report is related to its possible effect upon the natural development of the graduate program at Brock University. It is not our intention to attempt to introduce a Ph.D. program within the next five years. Nevertheless, the strength of the existing M.Sc. program, and cross-appointment of two members of the Department to the Ph.D. program at McMaster University, provide a nucleus for expansion into Ph.D. work during the decade. This possibility must remain open.

In our view there appears to be a conflict between Recommendations 4a and 4b. If periodic reassessment of M.Sc. institutions is to occur,(4b), while at the same time the number of Ph.D. programs is to remain at ten, or, perhaps, to be reduced, it would appear that a useless exercise is contemplated. If, however, quality is to be the key to program retention or initiation, the number of programs is irrelevant. Limitation of number should then occur only by consideration of quantitative aspects of the resources of the Province.

The general scope of the criteria established for sound Ph.D. programs, Recommendation 3, is quite satisfactory. However, some quantitative aspects appear to be unrealistic. If these guidelines were adopted today, chemical education in the Province would suffer severely. In particular, highly competent chemists would be prevented from participation in advanced graduate education and the educational advantages that accrue from the existence of small well-knit bodies of graduate students would be lost. Quality is not a function of the size of the faculty complement or student body alone.

Judgement of the quality of a program and the competence of the faculty is not to be achieved by the simple application of a rule related to success in achieving NRC support. Many other factors must be considered in a manner similar to that adopted in program appraisal as carried out by O.C.G.S. There appears to be little evidence of such consideration by the consultants.

Apart from the concerns expressed above, we have some comments on Recommendations 1, 2, 5 and 12.

1. We are encouraged by the statement that the level of provincial expenditure for the support of graduate studies and research is not considered to be high. It is difficult to envisage a mechanism by which savings that result from declining enrolments in one program can be diverted to other programs.

2. We are not convinced by the report that the overall quality of Ph.D. programs will be improved by the elimination of some programs.

5. We are in complete agreement with this comment. Although others have said it before, we have yet to see any provision for its implementation.

12. We strongly endorse this recommendation. The restrictions placed by government on the support of foreign students from grants and the recent adoption of stringent regulations for the employment

of foreign students have served to reduce the complement of foreign students to an almost negligable value.

CARLETON UNIVERSITY
RESPONSE TO THE FINAL CONSULTANTS' REPORT
ACAP CHEMISTRY PLANNING ASSESSMENT

Commitments and Procedural Requirements

The consultants' opening sections concerning the commitments within and without the university necessary for meaningful graduate studies and research are quite general and most appropriate not only for chemistry but for other disciplines as well. They are to be commended also for the tenor of their remarks on procedural requirements and working conditions with the emphasis on the achievement of excellence. Given the realities of the sixties, however, and the pressing need to increase the output of persons trained in chemistry, which even in retrospect the consultants find to have been justified, it is hardly surprising that the procedures actually employed fell somewhat short of the ideals set out in this report.

Sizes and Costs of Departments of Chemistry

The consultants next move on to the development of a hypothetical financial model of a department of chemistry. The significance of embarking on this exercise is said to be that "the name of this game is money" but it becomes clear that the purposes are first, to discover thresholds beyond which economies of scale tend to level off for undergraduate and graduate education; second, to arrive at rough costs per undergraduate course and per graduate student as a function of the size of departments; third, to get an estimate of the annual cost of research over and above the cost of instruction without research. If the results of this exercise had been validated and then used to estimate how much the Ontario government should spend for graduate studies in chemistry - one of the stated objectives of the exercise - the conclusions might have been meaningful and of considerable interest. The consultants do attempt to validate some of their assumptions in so far as they relate to numbers of student courses, faculty and graduate students by testing them against actual figures for the departments in the Ontario universities. They make no attempt to validate their hypothetical cost factors. They excuse themselves on the grounds that "no information directly relevant to these matters was provided for assessment. Undoubtedly, this omission was not accidental." Not only did they not attempt to avail themselves of their rights under their terms of reference to "obtain other data they may require to carry out the tasks ---" but they imply a motive, possibly sinister, for the omission of the cost information! The use of these unvalidated cost factors reduces the credibility of any conclusions which might be drawn even for the system as a whole, but the consultants go further and use them to derive costs for individual departments and set them down for comparison.

When we compare the costs set out in table III for Carleton, using the consultants' hypotheses, with our actual costs, the actual costs are significantly lower. In our opinion, the figures presented in Table III are not only unreal in absolute terms but may well be meaningless and even misleading for purposes of comparison, and we suggest that Table III be deleted from the report.

Among the conclusions drawn by the consultants using this financial model and its questionable cost factors are:

1) the costs for graduate research are not appreciably less in M.Sc. granting departments,

2) the most economical procedure for the presentation of undergraduate courses is in large universities which have a large relevant undergraduate base,

3) the net cost of graduate studies and research in chemistry in Ontario is about $7.0 million, which if nearly correct is less per capita than some other Canadian provinces,

4) the results of the exercise confirm the consultants' views concerning thresholds for the economic size of undergraduate only, M.Sc. and M.Sc. plus Ph.D. granting departments.

We do not suggest that the conclusions are necessarily incorrect, only that because of the nature of the factors used they are unproven.

Regarding Academic Excellence

After developing hypothetical costs the consultants move on to a consideration of the supply of students and the need for persons with post graduate degrees in chemistry. Admittedly, the problem of forecasting need is a difficult one and a degree of imprecision or hedging of bets would be understandable, even acceptable, but it is a source of some disappointment that the consultants chose not to attempt predictions as they were asked to do. Instead, they embark on an examination of developments of the fifties and sixties and conclude that while too many unqualified and basically untalented students were admitted to graduate work, and that there was a lowering of admission standards, nevertheless the overproduction of Ph.D.'s was not sufficient to cause undue alarm nor should there be any deliberate throttling down of Ph.D. production in Chemistry. While our inclination is to agree with the last statement it would have been comforting had the consultants produced some evidence

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of future trends in support of their statement.

After expressing concern about the calibre of students and the admission standards of the sixties, the consultants turn to an assessment of the quality or competence, breadth, and capabilities for graduate instruction and research of the individual departments in Ontario.

They base their assessment of the quality or competence of faculty members almost exclusively on one measure, the level of N.R.C. funding or grants awarded to the faculty member. While this is undoubtedly an important measure, it tends to favour established departments, not to take account of possible future potential, and reliance on it alone ignores other sources of support including that from the university itself. The on-site visits could have been used to seek out other evidence to complement this measure but seem not to have been used for this purpose, or else the consultants chose not to share such evidence with us.

In judging the breadth and capacity of departments for Ph.D. work the consultants have fixed upon a minimum standard in terms of size, distribution of faculty by rank and by fields of chemistry which in our judgement is too rigid. Surely an allowance could be made for post doctoral fellows as a substitute for some equivalent number of graduate students, the possibility of using distinquished adjunct professors in lieu of some full-time professors, to name just two possible variants to the model chosen by the consultants. The strengths or weaknesses of related departments such as Physics and Mathematics do not seem to enter in any significant way into the consultants' assessment, yet these are also quite important.

General Comments

In their next to the last section the consultants comment on facilities, operational costs, admissions and relations with industry.

We tend to agree that facilties in general are good and that investment in major equipment will be a continuing need.

We can agree also that any further cuts in the financial support for chemistry would be unwise, that quality should take precedence over quantity and that there should be more concentration on how better to spend the dollars and not on how many fewer dollars may be spent.

The desirability of students shifting departments or at the very least supervisors, between the B.Sc. and M.Sc. and again between M.Sc. and Ph.D. is accepted. The consultants' heavy emphasis on numbers in assessing departments would, if adopted, mitigate against students changing departments, we believe. The consultants' kind remarks concerning the efforts of the Discipline Group for chemistry are gratifying but we wonder whether these efforts, almost unique in Ontario, are not deserving of more attention and whether the consultants might

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not have set out more clearly a suitable role for this group's future activity.

We too hope that a Canadian industrial base will emerge in chemical or chemical related industries in Canada as a basis for a closer relationship between university departments and industry.

Recommendations

In their final section the consultants present thirteen recommendations. Much of our reaction to these is implicit in our earlier remarks and need not be rephrased here. We would like to add specific comments on some of the recommendations however, and will use the same numbers in referring to them as are used in the consultants' report.

Recommendation 1.

We accept the difficulties of forecasting the need for Ph.D.'s in chemistry but to recommend that such an attempt not be made seems to be going too far. The consultants' suggestion that savings from declining enrolments be employed to improve standards in staff and facilities should be directed to the government and not to the universities. Under the operating formula such savings do not accrue to the universities.

Recommendation 2.

We agree with the caution against overreaction to the seeming temporary mismatch between the number currently seeking the Ph.D. in chemistry and the number of openings available to them. It might indeed be wise to overproduce to a degree rather than to attempt an exact match as the consultants themselves suggest in justifying the overproduction beginning in about 1965.

The last sentence in this recommendation related to quality would seem more appropriately placed as a preamble to the next recommendation.

Recommendation 3.

This recommendation sets out under five headings the criteria for the acceptability of a department offering a Ph.D. While the minimum numbers proposed for faculty, graduate students and undergraduate courses are within our reach at Carleton we find the emphasis on numbers which seems to reflect a "bigger is better" mentality on the part of the consultants, disturbing. We referred earlier to the rigidity of the model used and again would point to the need to permit some departure from the numbers quoted based on qualitative considerations.

The consultants chose to consider the minimum size of a department capable of Ph.D. work on the basis of a model which treats each department in isolation and tends to ignore the existence of other departments within the system. If one were to start with the premise that each university in Ontario should offer undergraduate education in chemistry and graduate education at least to the M.Sc. level and then were to examine the role to be played by the system as a whole one might be

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led to quite different conclusions concerning the desirable size of departments generally and departments offering a Ph.D. in particular.

Apart from the numbers used the criteria as stated seem reasonable. We do not accept, as we pointed out earlier however, the single measure of N.R.C. grants used in the consultants' report for assessing the worth of faculty as a method for establishing whether the second criterion has been met.

Recommendation 4.

We are prepared to accept a threshold to be exceeded by Ph.D. granting departments by 1978 but not the rigidly quantitative model of the consultants. In general, we support the concept of appraisal approximately every five years for departments whether over the threshold or not. Appraisal involves a very thorough examination of the strengths of a department and its capacity to offer the Ph.D. degree.

Recommendation 6.

We endorse the need for complementarity and the avoidance of unnecessary duplication in developing the special strengths of departments, especially those in close geographic proximity. Carleton has consciously endeavoured to be complementary rather than competitive with the University of Ottawa. Agreements are in effect and are actually used covering the exchange of students and we have cooperated in the use of major equipment.

Recommendation 7a.

Carleton has already moved in the direction of involvement in research related to ecological and environmental problems. Four of our faculty are working in this area with the support of government and industry. We support this recommendation wholeheartedly.

Recommendation 7b.

This recommendation concerning molecular phenomena seems to ignore the role to be played by biology. Our biochemistry program recognizes the interdisciplinary nature of biochemistry and has already proven a success at the undergraduate level. The tradition at Carleton is to develop excellence at this level before embarking on work at the higher levels.

Recommendation 8.

We endorse this recommendation concerning the care to be exercised prior to introducing applied research into universities and believe that it should be reinforced. There is no place for product development in a university chemistry department but basic work, whether mission oriented or not, is of value and must be stressed.

Recommendation 9.

This recommendation concerning care in the granting of tenure is accepted but should be directed to the universities since to a considerable degree chemistry departments must follow university practice.

Recommendation 11.

We support this recommendation concerning the broadening experience of students doing graduate work at a university other than the one at which the undergraduate degree was obtained. It would have been helpful, however, had the consultants examined the proportion of home-bred students at each university - which they could have done easily - provided the relevant statistics, and made more specific recommendations.

Recommendation 12.

We accept the concept of financial support for some students presently disqualified by reason of citizenship or immigration status. Carleton makes awards without regard to age, sex or citizenship, and we wonder if the consultants have found evidence that this has not been happening elsewhere to the extent permitted the universities. The consultants' recommendation requires endorsement at government level to become effective.

In conclusion, we can accept the logic in a planned growth of graduate studies in Ontario but with due recognition for the right of individual students to choose among the programs offered by the various institutions and for the desires of such students to be associated with specific individuals. We believe that in chemistry the Discipline Group could play a significant role in accomplishing these objectives. It might for example, establish enrolment targets and guidelines as to admission standards, set up an Applications Committee to interpret these goals and standards, generally monitor the intake and distribution of graduate students and relate these to the needs of Ontario and the strengths of the individual departments, and finally keep COU advised of progress and the necessity for any corrective measures. We hope that COU will give serious attention to the procedures to be followed and the role of the Discipline Group as it considers the report of the consultants and the responses of the individual universities.

CONSULTANTS' REPORT - CHEMISTRY PLANNING ASSESSMENT

University of Guelph Comments

The University of Guelph regards this report as a thoughtful and thought-provoking plea for the highest possible quality of graduate programs in chemistry. We endorse much of the report and comment more critically on other aspects, particularly on matters which are basic to the consultants' assessment of quality. We regret the lack of major comment on inter-university cooperation.

General Endorsation

We endorse the consultants' brief statement (p. A-5) of the "ephermeral," some would say human, attributes which are factors in the success of a graduate program. Their points (pp. A-5 to 11) about appointment, promotion and tenure we regard as being generally well made; although we note the inconsistency by which an assistant professor, who should not receive tenure until after five to seven years, seems to be relegated to a kind of limbo in evaluating the strength of a department, regardless of the research support he may receive from NRC and other bodies. The consultants assert (pp. A-26, 27) their concern not for numbers but for the quality of Ph.D.'s graduated and the quality of Ph.D. programs. It may be expected, therefore, that they would urge the continuation of high quality programs with high quality graduates regardless of the market for Ph.D. chemists in the next decade,

....

which they "are not enthusiastic about predicting." The central role of chemistry, both in society at large and in education in particular, is set out in pages A-50 and 51. Few universities would deny the consultants' viewpoint. It seems clear that it is therefore a matter of vital concern to a university to have a demonstrably strong chemistry department. We are less convinced that strength flows from a graduate student group only if it numbers 30 or more. We do not find a justification for this number, and we wonder how it is arrived at. We suggest that many of the values sought through the activities of 30 graduate students may be achieved in alternative ways.

We endorse the consultants' generally optimistic view (pp. A-30, 31) of the employment opportunities for Ph.D. chemists in the next decade. Likewise, we support their statement of the importance of research to the quality of undergraduate education (pp. A-50, 51). We share with the consultants the concern (p. A-52) that students not remain at one university for all their university studies, and that students change research supervisors between their advanced degrees. The University of Guelph's well-known role in international education enables us to support the statements on page A-53 concerning gifted students from abroad. And we look forward to developing with the chemical industry the cordial relations we enjoy with other industries in other fields of activity at Guelph.

....

The Hypothetical Financial Model

We have studied with interest the Hypothetical Financial Model constructed by the consultants. We think it important to to emphasize that it *is* hypothetical -- the consultants themselves note (p. A-13) the lack of financial information provided to them. Its hypothetical character is made clear by unwarranted, but basic assumption (in B2, p.A-18) that a full-time GTA can serve three classes of 20 students each. (It is clear from p. A-19 that each such class is a 3-hour laboratory.) The provincial government places a limit of 10 hours per week *total time* on a GTA; thus it is necessary to assume that a GTA could carry *no more than 2* classes of 20 students. The universities of the province have agreed that such a full GTA may be held for no more than 2 of the 3 terms each year (260 to 300 hours total). The maximum payment permitted by the provincial government is $1,200 per term ($2,400 per annum). Thus, the GTA costs for three classes of 20 students would be, not $2,500 per annum, but $3,600 per annum, since the task would require 1.5 GTA's.

The overhead cost for an M.Sc. or Ph.D. student in a Ph.D. granting university is assumed to be $10,000 per year while that for an M.Sc. student in a department limited to an M.Sc. program is $5,000 per year. However, the rationale for these numbers (p. A-23) reveals that the costs are those associated with any first class research operation. Thus, the model predicts

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that when a Department with 40 M.Sc. students and 20 postdoctorals takes on one Ph.D. student, the fixed overhead cost for graduate students increases by $100,000 per year! The fixed overhead costs depend also on types of research emphasized, and on the degree of diversification.

The consultants conclude that the most economical procedure for the presentation of undergraduate courses is in large universities which have a large relevant undergraduate base. The reason the model leads to this result is the higher ratio of courses to classes (i.e. larger average class sizes) assumed for the larger universities (Table 1). This statement is therefore nothing more than an endorsement of larger class sizes. One is left wondering why the consultants did not make the obvious extrapolation to one TV class in each course, given on a province-wide basis. The point is really that any assessment of economy of undergraduate instruction has little meaning unless some consideration is also given to its quality.

A point concerning cost which seems to be continually overlooked is that universities in the Ontario system, because of formula financing, produce a given product at exactly the same cost to the taxpayer. The only relevant consideration is, therefore, the quality of the product, or really, what the taxpayer gets for his money. While it may be true that an individual Ph.D. program is costly to the university in terms of dollars per student

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graduated, the program may be of enormous importance to its overall academic objectives, even if it is of a very modest size. Individual universities are in the best position to evaluate their own priorities within the financial limitations imposed by the formula financing system.

The Matter of Quality

In their Assessment of the Quality of Graduate Programs (p. A-31 *et seq.*) the consultants cite criteria established by the American Chemical Society. In their discussion of (d) (p. A-32), the consultants refer to a critical number of graduate enrolments in terms of an annual "production" of Ph.D.'s. It seems to us that the benefits of a graduate program may well flow from additional kinds of associations. We suggest that interaction with a postdoctoral researcher is no less beneficial than with another graduate student. The consultants themselves speak well of postdoctoral fellows at the bottom of page A-17, where they appear to imply the possibility of postdoctoral fellows taking the place of Ph.D. students. They might have gone on to point out that in 1972 only Toronto and Western Ontario had a greater number of postdoctorals than Guelph. We discern in the 1970's a trend away from the research empires of recent years toward smaller groups with a higher proportion of postdoctorals. For example, Rockefeller University, with a faculty which includes at least two Nobel laureates,

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would apparently not meet the criteria of either ACS or the consultants, for there were but 28 graduate students in 1972 (the 54 postdoctorals would not be recognized -- unless our suggestion were accepted). Further, we are of the opinion that total numbers of graduate students are of less significance than the numbers in individual research groups, seminar groups, and the like. Finally, we regard the contribution of the individual research supervisor as of paramount importance in determining the quality of a Ph.D. student.

The NRC Grants

The consultants' use of NRC grant data as a basis for evaluating a department's strength is an interesting but, we suggest, less than fully valid basis for making such important judgments. It is particularly questionable to make judgments on the basis of a "snapshot," instead of a series which could suggest trends, such as may be seen in comparing the Guelph 1973 figures with those for 1972 (taken from the consultants' table, page A-37).

	PROFESSORS		ASSOCIATE PROFESSORS	
	Total	Average	Total	Average
1972	$ 45,510	$15,167	$62,000	$6,200
1973	$ 71,500	$17,875	$75,500	$7,500

In any case, there appears to be some basis (Council of Canadian Universities Chemistry Chairman, November 1972) for concern that

....

the system, good as it is, tends to favour those who have been in it longer. We believe the grants committee concerned does its best to be fair and objective, but we also believe that the NRC grant data cannot provide an infallible measure of the faculty research competence of a department. Reference is made, earlier in these comments, to the curious ambivalence of the consultants with regard to assistant professors. The exclusion of this rank from the NRC lists appears to disregard the recognition, after a three-year starter grant, of even a very promising researcher whose contribution to his department may well be much more significant than that of a senior colleague whose research activities are chiefly behind him. In 1973, for example, a tenured assistant professor in biological chemistry at Guelph received $15,000 from NRC (and half as much again from other sources), yet he is not included. His exclusion results in a misleading picture of the real strengths of Guelph in a field which the consultants regard as relatively weak in the province at large.

Guelph Growth

The University of Guelph wishes to record its concern that its growth potential appears not to have been recognized. In each of the past four years total grant support has shown significant improvement. An expansion of nearly 50 per cent is expected between December 1971 and December 1977 in faculty positions. Table IX excludes

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those who have not received NRC grants during the past five years, thus three members in the 60+ range are not counted. Their replacements, plus an increase of between five and eight expected as a result of increasing science enrolments would result in eight to eleven new members by December 1977. In making appointments we should have in mind the opinion that we (along with four other Ph.D. universities) are considered "deficient in the number of competent and capable faculty at the professional level" (p. A-38). Our concern in this regard is to question the curious logic by which one of the other four is singled out (p. A-41) for favourable mention apparently because of its "long and excellent traditions for higher education." The Guelph traditions, nearly a century old, are almost as long and, in their own way, no less excellent than those of Queen's. And if past performance in meeting growth projections is any criterion, Guelph's growth potential is no less "important" than that of York (p.A-41). The attached Appendix and Comments sheet present graphically alternative devices for measuring growth at Guelph.

Biological Chemistry

A final place in which the report falls short is in recognition of unique or distinctive features of different graduate programs. We are encouraged by the consultants' views concerning the importance of studies of biological phenomena at a molecular level in a chemistry department, views which echo those expressed

....

in the Guelph five-year projection. We are disappointed, however, that they did not comment on Guelph's aspirations in this area. For several reasons we believe that we are in a better position to develop strength in molecular biochemistry and related areas than any other chemistry department in Ontario. First, we already have considerable strength in this area, not only among traditional biological chemists, but among our organic, inorganic, physical, and theoretical chemists, many of whom have strong interests in biological problems. As noted, we have considerable potential for growth and the major emphasis will be in biological chemistry and those areas most directly related to biological chemistry. Much of our present strength in biological chemistry is a result of a large undergraduate teaching commitment in this area. Finally, faculty members in the Department of Chemistry at the University of Guelph are involved in no less than seventeen formal collaborative research projects of a biological nature with faculty members in other departments (see Guelph submission on Support from Related Departments).

Comment on Recommendations

With regard to the consultants' recommendations (p. A-55 *et seq.*) our major reservations are expressed in what follows; the remaining recommendations we generally endorse.

Rec. 2: We would wish to see justification for the suggestion

. . . .

that the overall quality of Ph.D. programs could be improved by concentrating them in a smaller number of universities. A university's overall academic objectives may be highly sensitive to even a small Ph.D. program in this discipline or that. In the case of chemistry, where the Guelph department is in a period of expansion, the existence of a Ph.D. program which is producing high quality Ph.D. graduates (as testified by our External Examiners) enables the chemistry department to recruit the quality of faculty required to support the advanced studies and research in a large number of related departments, as well, of course, as maintaining a vigorous program in ahemistry _per se_.

Rec. 3: As indicated earlier, we contend that any minimum number of "students" should be stated as a number of graduate students _plus_ postdoctoral fellows. We consider it appropriate to follow the lead of reputable institutions, such as Rockefeller University, which have developed first class programs that do _not_ depend on large numbers. Bigger is not necessarily better. Ontario has had enough of intemperate recruiting practices and marginal standards!

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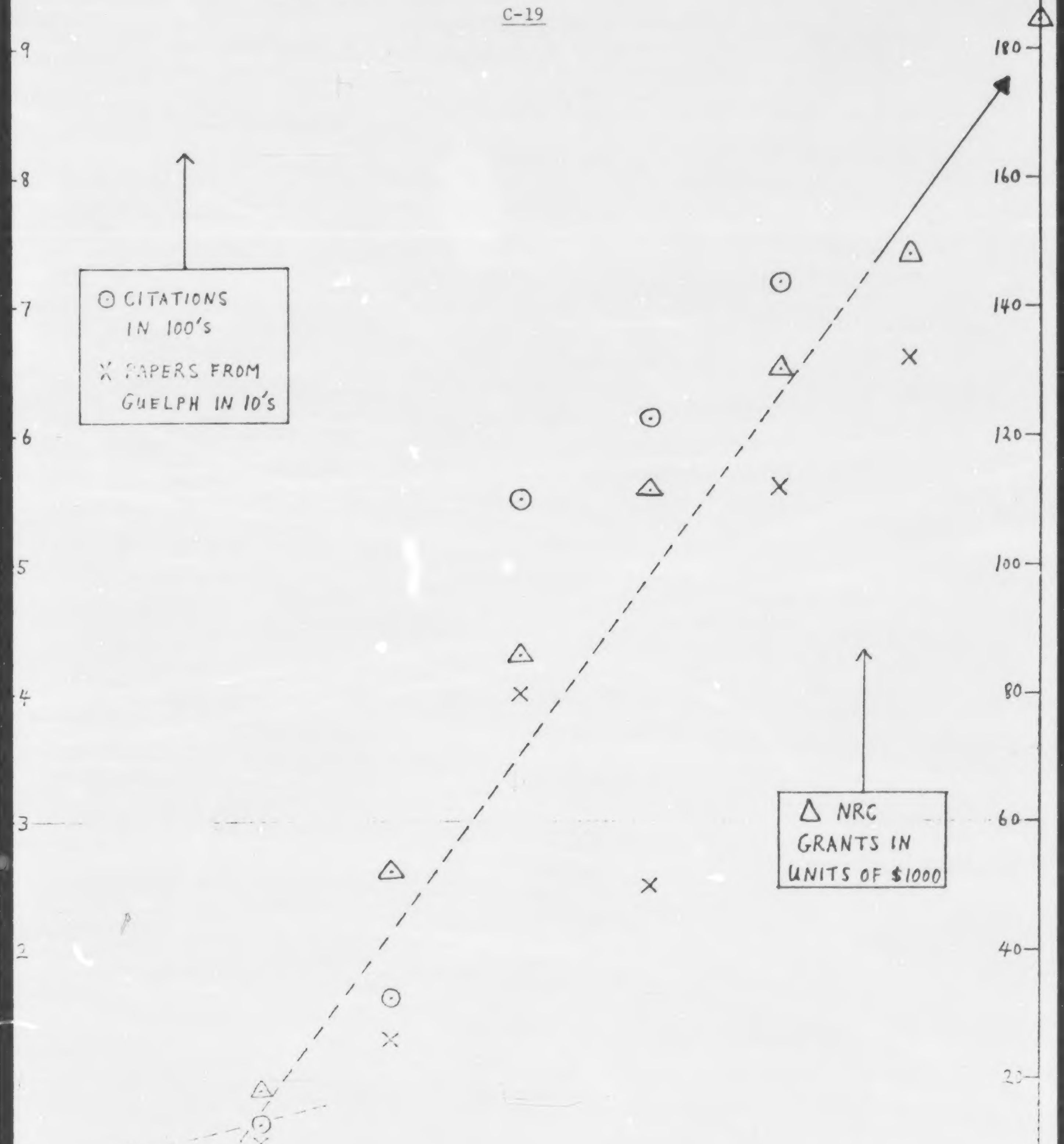
April 24, 1973

APPENDIX

CHEMISTRY DEPT., UNIVERSITY OF GUELPH

C-19



Comments

1. Publications are total for all faculty in a given year
2. N.R.C. grants are total for all faculty, excluding equipment and computing grants
3. (a) Citations are total in a given year for a given faculty member after he joined the University of Guelph
   (b) All publications of a given faculty member checked through first author
   (c) Citation of papers appearing before 1960 not included

TELEPHONE 345 2121
AREA CODE 807

Lakehead University
POSTAL STATION P THUNDER BAY ONTARIO CANADA

April 25th, 1973.

Dr. M. A. Preston,
Executive Vice-Chairman,
Advisory Committee on Academic Planning,
Ontario Council of Graduate Studies,
Council of Ontario Universities,
102 Bloor Street West,
TORONTO, Ontario.
M5S 1M8

Dear Dr. Preston:

Re: Comments on the Consultants' Report for Chemistry Planning Assessment

The consultants are to be congratulated on the theme of their report which emphasizes quality of graduate education. We would agree that the present level of expenditure for the support of graduate studies in the Province is not high; furthermore, the mismatch between students with higher degrees and the openings available to them is a temporary phenomena - if indeed there is any mismatch at the present time.

The major parts of the report are primarily concerned with Ph. D. granting departments, and we propose to comment only on the recommendations which directly affect this University. We accept that recommendation 4b is warranted during the next five-year period, but we find it disappointing that the possibility of collaboration between faculty members in Ph. D. granting and non-Ph. D. granting institutions in the supervision of Ph. D. students is not seriously discussed in the report.

The consultants rightly emphasize the importance of graduate studies and research in any university, and we would have expected somewhat more discussion in the report of the role of the non-Ph. D. granting universities. The University certainly endorses the principles enunciated in recommendation 5, yet it is disturbing that the consultants do not propose a more detailed plan to put this recommendation into practice. It should be recognized that this recommendation is of major importance not only to the Universities which at the present time grant only M. Sc. degrees, but to some of the other Universities whose Ph. D. programs could be phased out. We expect that ACAP will produce a more explicit statement

....Cont'd.

or guidelines for the implementation of recommendation 5.

The University is in general agreement with the spirit of recommendation 11 and believes that the smaller universities could play a more significant role in graduate education, particularly for students who would continue Ph. D. studies at another University. However, the University feels that adoption of recommendation 11 as it stands would succeed only in rotation of students between the Ph. D. granting institutions together with a drastic reduction in M. Sc. student numbers at non-Ph. D. granting institutions. This would seriously curtail active involvement in research work by faculty members of those departments not authorized to other Ph. D. programs, and this would be contrary in part to recommendation 5.

The University, therefore, suggests that if recommendation 11 is adopted, steps should be taken to stimulate and develop the graduate programs of those Universities not operating at the Ph. D. level.

The University endorses recommendation 12 and urges that ACAP treat this as a matter for urgent action.

Yours sincerely,

ANDREW D. BOOTH,

President.

ADB/lp

RESPONSE TO THE CHEMISTRY CONSULTANTS REPORT TO ACAP FROM McMASTER UNIVERSITY

McMaster University is in general agreement with the findings of the Chemistry Consultants and concurs with most of its recommendations. We are concerned, however, about Recommendation 4A which delays action regarding planning of Ph.D. programs until 1978. As will be shown in this presentation, failure to act more positively in the immediate future will lead to a very considerable decline in the quality of graduate work in Ontario.

The consultants do not deal in any detail with the sensitive topic of graduate student numbers. Although the report does deal with the minimum number of students which is necessary to maintain an accredited Ph.D. program (Recommendation 3), it does not deal with the related problems of the need for graduate students in our society or their availability. The consultants were specifically charged with predicting future requirements for graduates. We agree with their opinion that such forecasts can not be reliable, particularly when studied at a provincial level. In relation to student availability, however, reasonably reliable predictions are possible. The data provided in this response turns out to have important implications in terms of the number of viable Ph.D. programs that the Province of Ontario can expect to maintain. In this context the question of forecasting graduate requirements does not appear as a vital issue.

The data provided by the Chemistry Departments of Ontario to ACAP show that 263 Canadian students and 273 landed immigrant and visa students were registered in Ontario graduate schools in 1971-72. It is important that we examine these numbers and attempt to forecast how they may change. These same data showed that in 1971-72 181 students graduated in Honours Chemistry and Combined Honours Chemistry Programs. It is unreasonable to expect all of these students to continue their education in graduate school. Several alternatives are apparent: some students from combined programs will enter graduate work in Physics, Geology or Biology; some students will not have the standing required to enter graduate school; many, particularly a group in Applied Chemistry, may reasonably be expected to accept positions in industry or government; others will have interests such as teaching school. It is impossible to fix a percentage for those who might enter graduate school but it is unlikely that it would exceed 50% and it might be significantly less. On this basis, one might expect no more than approximately 80 students to undertake graduate work in Chemistry in a given year from our own undergraduate programs. Presumably gains and losses with other provinces would roughly balance each other.

Although a Ph.D. student takes an average of 4.4 years for a Ph.D., many leave after a lesser number of years with or without an M.Sc. degree. Therefore on the average a student will remain only about 3 years in graduate work. Thus, we see that the 263 Canadian graduate students who are currently enrolled in Ontario is a reasonable number in terms of our undergraduate enrollment; and the undergraduate enrollment in the junior years shows that no great change can be expected in the next few years.

The health of any graduate program requires a component of foreign students bringing in a different educational background, since a major part of graduate education involves student-with-student interaction. It is difficult to estimate how large this component should be but 20% would not seem to be unreasonable. We should realize, however, that current restrictions which relate to both federal immigration policies and provincial support policies have virtually stopped all foreign student input. With existing government policies, we may find that our graduate population will fall below the 300 level as the foreign component of our graduate schools is decreased This is not, in our opinion, a sufficient number to support the 10 Ph.D. programs currently operating.

It is important that we attempt to predict how students will distribute themselves in the event that no action of any type is taken before 1978. It could be argued that the students themselves will seek out the best programs and the system will become self regulating. In the current year McMaster, Toronto and Western exchanged the names of their graduating honours students in an attempt to ensure that they would be familiar with the programs at the other institutions. It is too early to state the effects of this, but it appears there may be no students exchanged as a result of this action. Indications are that one student may decline an N.R.C. Science Scholarship in order to remain at his parent university. Data collected by the Chairmen of Ontario Chemistry Departments have shown thatfewer than 15% of the students in the province move to another university in the province at the start of their graduate program. Indeed, the 1973 NRC list of awards to students entering graduate school in Canada indicates that only 6 out of 35 students awarded an NRC Scholarship in Chemistry intend to move away from the institution where they received their bachelor degree. Unless more drastic steps are taken than those suggested in Recommendation 4A, which delays decision regarding continuation of Ph.D. programs until 1978, there is a danger that all graduate schools in Chemistry will have a parochial population directly reflecting their own undergraduate numbers. The universities, under such conditions, would almost certainly reach a common level of mediocrity.

We heartily endorse Recommendation 11 of the consultants report together with the rationale on page A-52 which discusses the mobility of students. There is, however, no mechanism suggested for dealing with this problem and unfortunately the self-survival instinct of the various universities is leading to the retention of their own students.

It is to be anticipated that, as the student shortage becomes apparent, there will be discussion concerning the merit of a few large graduate schools as opposed to the students being distributed amongst all of the universities currently authorized to offer the Ph.D. We believe, as do the consultants, that there is a critical size for a viable Ph.D. program. Whereas the consultants have reached this conclusion on academic grounds, we should realize that financial considerations are also important. Although the financial model developed by the consultants implies that the cost of maintaining a graduate student is not significantly dependent on the size of the graduate school, the analysis does not include the capital cost of providing their equipment. The substantial funds required for this can only be provided in large graduate schools where the equipment will be adequately used. Federal funds, which are now the main source of such capitalization, are already spread too thinly to maintain our current standards. At the meeting of the Chairmen of Chemistry Departments of

Canada held in November 1972, the problem of providing and maintaining appropriate research equipment was identified as the major problem at the present time. It certainly will not be economically feasible to provide adequate equipment if the graduate schools only have a small number of students.

It is possible that the immediate publication of Table VIII of the consultants' report, which assesses the strengths of the various Chemistry departments, could act as a "consumer report" and the students would polarize to preferred institutions. It is our belief, however, that stronger action regulating the number of departments offering Ph.D.'s will be required. The conditions outlined in Recommendation 3 of the consultants' report represent a reasonable basis for immediate action.

C-28

UNIVERSITÉ D'OTTAWA
550, RUE CUMBERLAND

UNIVERSITY OF OTTAWA
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OTTAWA, ONTARIO
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CABINET DU RECTEUR

OFFICE OF THE RECTOR

April 26, 1973

Dr. M.A. Preston,
Executive Vice-Chairman,
Advisory Committee on Academic Planning,
Ontario Council on Graduate Studies,
Council of Ontario Universities,
102 Bloor Street West,
TORONTO, Ontario, M5S 1M8.

Dear Dr. Preston,

This is a reply to your request for the University of Ottawa reaction to the A.C.A.P. Chemistry Consultants' report.

Firstly, we should like to congratulate the consultants for the objectivity of their report. They have based their conclusions solely on academic excellence; they have defined their criteria for assessing academic excellence; and we find this highly commendable.

We should like also to echo the cautionary words of the consultants concerning the limitation of graduate students in Chemistry in Ontario through fear of over-production of chemists. The availability of a corps of well trained chemical specialists could be vital for the solution of many of societies technological problems and an undue reduction in the number of Ph.D.s in Chemistry could be disastrous for the economic development of Canada and for the facing of emergencies in the present technological era.

We regret their omission of any reference to the bilingual vocation of the University of Ottawa and should like to point out that two of the most recent recruits to the staff of our Chemistry Department are French-speaking professors.

It should be emphasized that the absence of professors specializing in Biological Chemistry from the list of staff of our Chemistry Department is in accordance with criteria established for this assessment. However, in some universities biological chemists are located in the Chemistry Department and they are therefore included in this assessment. Three years ago we transferred the two full professors specializing in this field to our Department of Biochemistry which we believe to be one of the strongest Biochemistry departments in the Province. Thus, although expertise in this field may be lacking from our Chemistry Department as such, it is still available on the campus, in fact in the building next door. Moreover, this transfer of the two biochemists freed two laboratories in our Chemistry Department for occupation by two new francophone professors of Chemistry. In view of the consultants' remarks on the tightness of space in the Chemistry Department, the significance of placing these two biochemists in another department while keeping their special qualifications available to the Chemistry Department assumes special significance.

Since you have asked that we discuss our relationship with Carleton in the matter of Ph.D. programs, I should like to emphasize our willingness to collaborate with Carleton University in Chemistry as in other disciplines. As you know, special arrangements exist for students at the one university to take courses at the other. In the case of Chemistry, the two departments have been working independently and possibilities for collaboration remain to be explored.

Yours sincerely,

Roger Guindon

Roger Guindon, O.M.I.,
Rector.

c.c. Dr. P. Hagen
Dr. A. D'Iorio

QUEEN'S UNIVERSITY
KINGSTON, ONTARIO
SCHOOL OF GRADUATE STUDIES AND RESEARCH

23 April 1973

Dr. M. A. Preston
Executive Vice-Chairman
Advisory Committee on Academic Planning
Council of Ontario Universities
102 Bloor Street West
Toronto, Ontario
M5S 1M8

Dear Dr. Preston:

Attached are the tentative comments from Queen's University concerning the Report of the Chemistry consultants. These comments are based on a review by the Development Sub-committee of the Faculty of Arts and Science. As mentioned in previous cases, the comments are unofficial in that Senate has not had an opportunity to study the Report.

I feel confident that Queen's will wish to make more substantive comments at a later date on some of the implications contained in the body of the report. Presumably such an opportunity will occur when the ACAP report is submitted to COU.

Yours sincerely,

J E Hogarth

J. E. Hogarth
Acting Dean

JEH/mb
Attach.

P.S. Please note and correct an error in Table IX (Page A47). The age groupings for Associate Professors at Queen's is eleven in the range 35 - 39 and one in the range 40 - 44.

J.E.H.

QUEEN'S UNIVERSITY
KINGSTON, ONTARIO
SCHOOL OF GRADUATE STUDIES AND RESEARCH

Comments on the Report of March 23, 1973 of the Chemistry Consultants to ACAP

A. Comments on the Recommendations:

1. We endorse all of the Recommendations with the exception of 1, 3, 4, 7b.

2. We could endorse Recommendation 3 if the judgments of "strength", "competence" and "sufficient eminence" in a department were made only after a full appraisal by OCGS.

3. We could endorse Recommendation 4 also if the decision to introduce or discontinue Ph.D. programs in a department were made only after a full appraisal of that department by OCGS.

B. Comments on the explicit criteria developed by the Consultants:

1. We question the methodology and analysis of the Consultants' Report without necessarily disagreeing with the conclusions. The Consultants have opted for an analysis of the state of chemistry in Ontario, based almost entirely on 1972 NRC grants. While such evidence is undoubtedly of importance to such a study, the fact that it has been used in such extreme isolation severely limits the value of the report.

   NRC grant figures are publicly available. Surely ACAP should expect at the very least some independent judgment from the Consultants as to the correlation between NRC awards (say over a five-year period) and the excellence of a department's graduate program. The assumption, without examination, of nearly 100% correlation, is not acceptable. It appears that the approach of the Consultants to this problem has been based much more on the methods of assessing competence in research current in the context of many large American Universities than on those appropriate in the Province of Ontario.

   We regret that the Consultants did not make explicit the other factors referred to on Pages A36 and A42 which led them to their conclusions.

   It is to be hoped that ACAP will comment extensively on this aspect of the Chemistry Consultants' Report.

2. We feel that ACAP might wish to consider the points made in a brief submitted in February, 1969 to COU by the Committee of Chairman of the Departments of Chemistry of Ontario Universities (CCDCOU). In that brief it was suggested that departmens could be considered in terms of areas of excellence and areas of concentration. Such an area or sub-discipline might involve only

one member of staff, or might represent the combined cooperative research of a number of faculty members. Whether or not a particular department should accept Ph.D. candidates would depend on the ability of that department to support and complement graduate instruction in the areas of excellence and of concentration. Factors to be considered would include the overall graduate program required for the degree; the dedication of members of faculty to the formal and informal instruction of graduate students other than their own; the *esprit de corps* in the department; and the strength of other departments of the university in the physical and life sciences, and the degree of cooperation between these disciplines and chemistry.

J E Hogarth
J. E. Hogarth
Acting Dean
School of Graduate Studies and Research

23 April 1973

C-33

OFFICE OF THE VICE-PRESIDENT
INSTITUTIONAL RELATIONS AND PLANNING

UNIVERSITY OF TORONTO
TORONTO 181, ONTARIO

April 30, 1973

Dr. M.A. Preston
Executive Vice Chairman
Advisory Committee on Academic Planning
Ontario Council on Graduate Studies
102 Bloor Street West
Toronto Ontario

Dear Dr. Preston:

I am writing to give you the University's comment on the Consultants' Report on Departments of Chemistry.

Our main point is that we support the thrust of the recommendations made in the Report, but we feel that the Consultants have failed to follow through on the logic of their assumptions about the nature of graduate work and on the evidence in this field in particular. The analysis of the characteristics of faculty by departments, their views on the viable number of faculty and of graduate students for a graduate programme, plus the general philosophy underlying the study, in each case point to concentration of Ph.D. work in particular in fewer universities. Yet recommendation 2, on p. 55 seems to back away from this somewhat while recommendation 4a points to a process for rationalization of doctoral work which might take as long as 10 years to implement fully. Since the conclusions of the Report point to the need for some degree of further adjustment beginning now, and since as noted below there are very large costs to any delay, one wonders why the process is to be drawn out in this way.

I am well aware that if some Ph.D. programmes are terminated there will be some difficult problems in phasing out the operations. There must also be some provision to assure that the staff members can remain involved in research in some form and that the needs of undergraduate teaching continue to be met. But I believe that a long drawn-out process will do damage ultimately to those departments most directly affected, to the discipline as a whole, and to the students.

May I suggest that A.C.A.P. might wish to ask the Consultants or others to seek within the near future other evidence to test the evaluation of departments which this report produced by looking at N.R.C. research funding. Except where such alternative methods show major changes in the classification, we would urge A.C.A.P. to recommend an immediate start on planning to implement these proposals in a sensitive and constructive way.

The Consultants should be commended for attempting to devise a method to assess the costs of undergraduate and graduate studies and research. Unfortunately, there appears to be a major flaw in the estimation of costs per student which vitiates their statistical conclusions and undermines their view that only small savings exist in having larger graduate programmes. According to Table 1, the costs per graduate student are virtually stable as you go from medium-sized to larger graduate programmes. This is a very unusual form of unit cost curve.

A unit cost curve has two components, variable costs which expand with output and overhead costs which are fixed. It is the spread of the fixed costs over a larger number which brings most unit cost functions down for a certain range of numbers. It is true that the large payroll component (a variable cost) will tend to give a unit cost curve which does not plunge sharply as numbers expand. But the consultants have, in effect, abolished fixed costs by assuming that they are a fixed percentage of faculty payroll. I refer, for example, to page 20, where fixed overhead is 50% of payroll, and page 22 where costs of research are 40% of payroll plus $5000 or $10,000 per year per graduate student. Since fixed costs have become variable in the sense that they are a fixed per cent of a variable cost, it is not at all surprising that the cost per graduate student does not come down as the number of graduate students expands. If certain kinds of equipment costs which apparently were neglected were also taken into account, the decline in unit costs would be accentuated. If I have understood their methodology, then the last column of Table 1 is quite misleading and conclusions based on it suspect. In particular, the view that there would be no savings in reducing the number of Ph.D. programmes is quite unsustainable once it is recognized that cost per student falls as number of students rises. Furthermore, these calculations do not include costs for major equipment. The problem of maintaining equipment at high standards is becoming serious with roughly constant grant size and diminishing Departmental budgets. Significant savings could be affected and standards could be better maintained if major equipment was distributed over fewer Departments.

I note on page 38 and 57 a comment and a recommendation regarding our Scarborough and Erindale campuses. I want to emphasize that neither the administration of the Colleges nor of this University contemplate or plan separating into independent institutions. I want to emphasize also that there is only one graduate department of Chemistry in this University with a unified responsibility to the Dean of the School of Graduate Studies and the Governing Council of this University for purposes of maintaining student and faculty standards and in all other relevant respects.

Finanlly, in this Report as in some other, I am struck by the fact that what is recommended may have a significant effect on the teaching of undergraduate programmes. While the focus of these reports is the graduate programmes, I believe A.C.A.P. should consider instructing the consultants to comment on the possible effects of their recommendations on undergraduate teaching wherever these are significant. I am sure that Universities will themselves ask that kind of question given any major changes in their graduate programmes.

Sincerely yours,

JH Sword

J.H. Sword
Vice-President
Institutional Relations and Planning

JHS:lc

TRENT UNIVERSITY

GRADUATE STUDIES & RESEARCH IN CHEMISTRY IN ONTARIO UNIVERSITIES

The Consultants' Report, commissioned by ACAP, on graduate studies and research in the chemistry departments of Ontario universities addresses itself mainly to the ten doctoral-granting universities. Accordingly it has little relevance to this department.

Though in general we approve the tenets of the report and its recommendations, we are sceptical of many of the report's quantitative assumptions and of the conclusions derived therefrom. As one example, to use a 25% increase over the next nine years as a basis on which to plan staff increases (page A-17) is to display exactly the lack of foresight of which the consultants (page A-8) complain. Population statistics (see COPSE report, Table 8-2) demonstrate clearly that any increase occasioned by an increase in the 18 - 24 age group will be a very temporary phenomenon. As a second example, we consider the exercise of computing the costs of educating graduates and undergraduates on the basis on an arbitrary and unsubstantiated model to be valueless, and comparisons based thereon to be dangerous. Such exercises are also unnecessary in the cases of Trent and other universities which practise an "open budget" policy. As a third example, we regret that the consultants failed (despite a request supported by all fourteen departments) to take into account, in their assessment of research competence, any financial support other than that derived from the National Research Council of Canada.

Response of the University of Waterloo
to the Report of the Chemistry Consultants
to the Advisory Committee on Academic Planning
submitted to A.C.A.P., April 19th, 1973

General Comments:

The report of the Chemistry consultants is concerned primarily with a critical evaluation of the Ontario Chemistry Departments, rather than with developing a forward plan for graduate work in the discipline for the next decade. This emphasis is perhaps understandable in Chemistry, because graduate work in this discipline has been planned by the Committee of Chemistry Department Chairmen for several years. The quality of the graduate students being admitted to the system has been monitored and the Chairmen have met regularly to discuss other matters of mutual interest. The reasonable level of current enrolments in the ten doctoral programmes in Ontario is testimony to the success of this effort. It is understandable then, that in this case the consultants would see their main task as one of conducting a broad appraisal of the departments concerned, since the relative quality of the graduate programmes would be a major factor in future planning.

The criteria which the consultants feel should be met by a department wishing to offer a Ph.D. degree in Chemistry, are set forth in recommendation 3. These criteria are certainly acceptable to the University of Waterloo in principle. Our only concern is that the criteria used to determine strength and competence in the various fields of Chemistry, be chosen with sufficient care to insure that the strength of a particular department is assessed as accurately and as completely as possible.

It is clear from the context of the consultants report, that they in referring to strength and competence are referring to the A and B ratings set out in Table VIII of the report. We believe that the criteria used in arriving at these ratings are too narrow. It is understandable that the consultants, in the limited time at their disposal, could not undertake the kind of careful and complete assessment of each department that would be involved in an academic appraisal. We appreciate therefore the reason behind their decision to fall back on the N.R.C. grant level scheme which they have used in their evaluation. We are even prepared to accept that this method of rating the departments will provide a reasonably accurate, if somewhat broad measure of quality in the three classical fields of Chemistry: Organic, Inorganic and Physical. It is not a valid measure however, even in a broad sense, in the more applied fields of Chemistry, such as Analytical Chemistry. In this field the level of funding provided by N.R.C. is substantially less than that in the three major fields of Chemistry and is not adequate to support all of the sound research as the figures in Table VII clearly show. Because of this much of the funding for applied research in Analytical Chemistry comes from other sources. In the funding of applied research the relevance and importance of the research problem itself becomes an important factor in determining the level of funding. A substantial level of funding for research in this area of Chemistry therefore attests not only to the competence of the individuals concerned, but also to the value of their work.

A second weakness in the approach used by the consultants in evaluating the departments, is that it is based on a rating at one point in time only and does not give any indication of future potential. Since the main objective of the planning assessment is to look to the future, this is a rather serious weakness and could give a distorted picture of the strengths of a department. Two important factors in assessing future potential are the strength of the assistant professors who were not included in the consultants evaluation and the rate of increase in N.R.C. grants received by the individual professors in the department. A department which has achieved a certain level of N.R.C. funding provided by relatively young full professors or associate professors whose grant levels have been steadily increasing and who are probably the future stars of the system, is clearly stronger than one which has achieved the same level of funding but has reached a relatively constant level of support. In addressing ourselves to the remainder of the 13 recommendations contained in the consultants report, we would first of all give our general support to these recommendations and secondly, draw particular attention to recommendation number 7. We endorse this recommendation and point out that Waterloo has one of the strongest groups in Analytical Chemistry in the province.

Specific Comments:

In their rating of the University of Waterloo set out in Table VIII the consultants have shown us as having strength in the field of Physical Chemistry and competence in the fields of Organic and Analytical Chemistry. We believe that this assessment fails to reflect our true strength in the field of Analytical Chemistry because it has neglected to take into account the substantial level of research funding which the members of our faculty in that group receive from sources other than N.R.C. In the grant year which is covered by the consultants report, the total of the research grants generated by our Analytical Chemistry Group was $46,900, $14,500 of which was from N.R.C. This represents a substantial level of funding and reflects more accurately the true strength of our programme in this field.

In attempting to assess the role which Waterloo might play in the future development of Chemistry in the province, we would point to the fact that the research grant level of our faculty has been increasing at a faster rate that the national average. Thus for this year 1973, the level of grants increased by 19% over the previous year, while the total increase in N.R.C. grants in Chemistry for all of Canada was only 6.8%. This increase occurred without any increase in staff and therefore reflects the growing strength of the faculty in the department.

In the field of Theoretical Chemistry, we believe that we have potential strength which is not truely reflected in the C rating given to this category in the consultants Table. In this case the strength of the department is represented to a large extent by junior people who show considerable promise. One member of this group received an N.R.C. grant this year which showed an increase of somewhat over 100% compared to last year, while another member of the group, whose N.R.C. grant increased by nearly 50%, was the recipient of a Sloan Foundation Fellowship, the only Canadian Chemist to be so honored in 1973. The University has further moved to strengthen its efforts in the field of Theoretical Chemistry by arranging for the cross-appointment of two senior Theoretical Chemists, who are members of the Applied Mathematics Department to the Department of Chemistry. This will provide the Theoretical Group with the necessary balance at the senior level and significantly augment the efforts of the junior people.

Conclusion:

In summary, we submit that the University of Waterloo has strength in the two fields of Physical and Analytical Chemistry, and competence in the fields of Organic and Theoretical Chemistry, with considerable potential strength for future growth in the latter field. On this basis, our department satisfies the criteria for maintaining a strong reliable Ph.D. programme in Chemistry,

Respectfully submitted,

L.A.K. Watt

L.A.K. Watt
Dean of Graduate Studies

LAKW/mw

Response of the University of Western Ontario to the Report of the Consultants in Chemistry of the Advisory Committee on Academic Planning.

April 24, 1973

This report was generated by a Committee of the Senate of the University of Western Ontario charged with preparing the University's response to the report of the A.C.A.P. Consultants on Graduate Studies in Chemistry.

The Committee would like to acknowledge the comprehension revealed by the ingenious model developed by the Consultants and to compliment them on the application of it to the contemporary problems of Chemistry. The analysis, founded as it is on quality, is very helpful in illuminating the strengths and weaknesses of Chemistry in the Province of Ontario. We would also support their courageous stand in recommending the support of a small number of well-qualified foreign students who presently fall outside the regulations of government-supported funding agencies (Recommendation 12). However, there are certain parts of the report which we feel bound to question:

1. A specific comment is necessary on the Consultants' remark on page A-38 concerning Western Ontario. While, of course, the fact that 6 of 12 Associate Professors received NRC grants of less than $5000, is not disputed, the Consultants' conclusion from the fact is challenged vigorously. First, it should be noted that three of those 6 Associate Professors are heavily engaged in administrative duties elsewhere in the University (50% of time in one case, and at least 75% in the other two) and hence play little or no part in the graduate programme. Secondly, this isolated fact concerning NRC grants of Associate Professors cannot be separated from the closely related facts that the Professors at U.W.O have the highest average NRC grant in Canada (Table IV, page A-37) and that, in age distribution (Table IX, page A-47) they are young. Bearing in mind that Associate Professor at U.W.O. is a career rank, it is surely at least as appropriate to examine the future of the chemistry graduate program at U.W.O. in terms of these outstanding young Professors, as in terms of the NRC grants of Associate Professors. Finally, it should also be noted that among the Associate Professors at U.W.O. is one very outstanding chemist (G.M. Bancroft - awarded the Steacie Memorial Fellowship for 1973), and that among the Assistant Professors (whom the Consultants did not consider in making these remarks) are several promising young scientists. These latter members of the Department will play a most important part in the future of our graduate programme.

2. We are disappointed with the nature of Recommendation 4a. The statement in 4a fails to come to grips with the problems created by the establishment of the criteria set out in Recommendation 3. If the sine qua non is fifteen full-time faculty members and thirty graduate students and all departments in the province are given five years to reach this objective in an environment of contracting enrollment and limited supplies of qualified applicants, the consequence will be an unprincipled scramble, by all departments, (in spite of Recommendation 11) to reach or maintain that arbitrary standard which permits them to initiate or continue doctoral studies. In our view this recommendation even allowing for the condition of a "wide margin" does little to face the problem of maintaining established areas of excellence in the face of the diminishing numbers of high quality students which seem inevitable.

We are disappointed also that the Consultants did not discuss their guidelines for minimum Ph.D. enrollment in relation to the present undergraduate base. If inter-provincial transfers between Ontario and other provinces remains approximately in balance, as it has been in recent years, the all-Canada base provides for the entrance annually of about 75 students to M.Sc. and Ph.D. chemistry programs in the Ontario system, corresponding to a steady-state enrollment in the neighborhood of 240. Even if this number were to increase by 25% to allow for immigration and admission of foreign students, there are barely sufficient students in the undergraduate years now to support a uniform minimum level of 30 graduate students in each of 10 institutions by 1978.

Since the undergraduate base is restricted, methods of dealing with forms of competition not based on excellence must be evolved if the areas of quality which exist are not to be decimated by the frantic efforts of others seeking to achieve the same level of distinction. It is difficult to see how this can be accomplished except by a temporary hold on Ph.D. enrollment in some institutions.

3. Deficiencies in Analytical Chemistry training at the graduate level have been identified (Recommendation 7a). It is the view of this University that not all institutions should seek to establish a high level of competence in all areas and that only a limited number of Departments should endeavour to develop the area of analytical chemistry.

4. We believe the data presented in Table VII (A-44) indicating a dearth of biological chemistry in the province are misleading. It will be recognized that significant parts of the budgets of agencies such as the

Medical Research Council, the Defense Research Board, the National Cancer Institute and the Department of Agriculture, to mention only a few, are committed to biochemical studies carried on in university departments. There is unquestionably an overlap between the research interests of chemists and biochemists and one may look forward in the future to increasing collaboration between these two groups but such collaboration need not develop along the lines of exclusion of one group or the other from particular areas of the discipline.

5. The possibility of establishing a common placement examination for graduate students is commented upon (A-52). The present mechanism of control of admissions excercised by the Committee of Chairmen of the provincial departments approaches this objective without introducing the inflexibility associated with a common examination. It was the view of this Committee that dangers inherent in the common placement examination are such as to make us wish to retain the present system which must be recognized as rather more stringent than any other province-wide regulations for admission of graduate students.

6. In a report of this size directed toward the long-term future of training in chemistry remarkably little attention is devoted to the post-doctoral fellow. These individuals play a particularly important role in the development and performance of research in chemistry and it is our view that any plan for the future should contain a clear statement of the perceived position of the post-doctoral fellow.

7. The report comments that there exists"...virtually no continuing relation between staff members and industry." Trent and Toronto are mentioned as possible exceptions. The Committee considers that efforts at Western in the design for commercial production of innovative types of instrumentation, and in co-operative ventures for the marketing of rare chemicals, also merit recognition.

University of Windsor Comments on the Chemistry ACAP Consultants' Report

(1) We consider that the consultants have produced an assessment of the Chemistry Departments in this Province which provides valuable guidance to all Departments including our own, for the future development of Chemistry in Ontario.

(2) However, we have some reservations about the Report:

I. A general regret, and one which surely has been voiced by many other people, is that consultants have relied heavily on statistical data. We regret this aspect of the Report, since such retrospective arguments cannot completely answer questions as to the future development of graduate work in the Departments of Chemistry in Ontario. Statistics, of whatever origin, necessarily reflect past performance, whereas it must be clear that Chemistry Departments will not necessarily maintain a constant level of research efficiency; some will improve, some will not. To take a particular point, the assessment of research capabilities is based on N.R.C. grants for the financial year 1972-1973. These grants were awarded by the appropriate N.R.C. committees in February 1972, and are based on applications made by individual staff members in November 1971, and must therefore largely reflect publications submitted to the journals by Spring 1971. This Department has undergone considerable change for the better since that time, and we would resent any attempt to assess its present capabilities on the basis of such out-of-date information.

II. The University regrets that the criteria used by the consultants necessarily favour the large long-established departments of this Province. Nobody would dispute the quality of the three largest departments in this Province. We resent, however, any implication that Ph.D.'s produced by this, or other departments of similar size, are of poorer quality than those produced from larger departments. We believe that many people who have been trained in the Department are now playing a useful part in the scientific life of this Province and elsewhere. We believe that future Ph.D.'s from this Department will carry on the same tradition.

III. The consultants in paragraph 3 of their recommendations draw attention to a number of criteria which they believe must be met by a successful Ph.D. granting institution. Amongst these is one which must be questioned, namely (3) that the undergraduate base should not be far below 1,800 full courses in chemistry each year. This is clearly something which this Department cannot meet in the immediate future. However, the University believes that this is surely a matter of internal university decision. If a department can be funded by the University in spite of an enrollment lower than 1,800, that is the University's choice and the University's decision to make. Moreover, there is nothing in the Report to validate the figure of 1,800. In this particular aspect, the consultants have relied over-heavily on their model.

(3) Given the shortcomings of the statistical data, and indeed of the nature of the whole operation of the ACAP assessment, the University believes that the Department has been fairly assessed relative to other departments in its position as of 1971, although we regret very much that no account has been taken of changes, actual or prospective, since that time. We fully accept the challenges implicit in the recommendation 3 and 4 (a) of the Report. We are confident that present shortcomings will be overcome within the five-year period recommended by the consultants, and that we shall have met these minimum requirements by a "wide margin" in 1978. We fully believe that changes in the Department which have been instituted in the past 18 months will have borne fruit by that time and that the Department can then be fairly assessed in the light of its achievements over the period 1970-1978. It is our intention to build on our present strengths, and we are confident that our performance in the next few years will fully substantiate our belief that we can satisfy the criteria laid down by the consultants.

(4) On page A-30 and A-31, the consultants emphasize the continuing need for chemists and believe that there should be no throttling down of Ph.D. production in chemistry. We agree with this, and further agree with their statement that the next ten years will show a handsome return on the investment in both plant and staff. This Department has now acquired much of the necessary

equipment, and has improved the quality of its staff in recent years. We have no hesitation of taking on the challenge of competing in the rarified atmospheres of chemistry in the fields which we shall mark out as our own. We believe that Windsor has entered on the early part of a growth pattern in the quality of its research programme and that by 1978 the results of this will be apparent to all concerned.

(5) We intend to continue our policy of specializing in certain areas, in which we shall make a significant contribution to the training of scientists, and to the advancement of chemistry in this Province. In particular, the Department has been committed for some time to an expansion of its activities in inorganic chemistry, and in the general area of biochemistry. We believe that we are well fitted for increased meaningful chemical research at the frontiers of investigation into biological systems, since we do not have complications with medical schools or conflicting biochemical interest within the University. We intend to continue to emphasize analytical biochemistry and clinical chemistry, in which we have been a pioneer amongst Chemistry Departments in this Province.

In conclusion, we emphasize that the University has an existing commitment to the development of its Department of Chemistry.

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YORK UNIVERSITY

4700 KEELE STREET
DOWNSVIEW ONTARIO CANADA

FACULTY OF GRADUATE STUDIES
OFFICE OF THE DEAN

April 18, 1973.

Professor M.A. Preston,
Executive Vice-Chairman,
Council of Ontario Universities,
102 Bloor Street West,
Toronto 181, Ontario.

Dear Mel,

York University accepts the general tenor of the recommendations given in the consultants' report on Graduate Studies and Research in the Chemistry Departments of the Universities of Ontario. The positive emphasis stands in marked contrast to the rather adverse publicity which Chemistry has received in the media during the recent years. The report recognizes the need for responsible planning by the universities acting together and its recommendations that any university should place a prime emphasis on improvements in academic standards are entirely appropriate to the proper role that the universities should play in contemporary society. The central role of Chemistry as an academic discipline and the part that chemical education plays in terms of its applications to many areas of human activities are properly stressed. That stress should be placed on quality rather than quantity in the further development of Chemistry in Ontario is commendable.

In accepting the general criteria of what constitutes quality in graduate programmes in Chemistry, York University expresses some concern regarding the weight attached to a single criterion, namely that of NRC grants by themselves. NRC grants may provide the best single yardstick for comparison of the "external visibility" of the various departments in the Province, but a combination of this and other criteria such as publications (appropriately weighted for quality) and grants and contracts from all sources, would form a more sensitive measure of academic quality. In the event that a further review of graduate programmes in Chemistry in 1978 should suggest that particular programmes have not approached the standards proposed by the consultants this University would urge that such programmes should be evaluated much more carefully before the authorization to accept further students into PhD studies be withdrawn. In such cases, this University would endorse the idea that programmes recommended for termination be reappraised by the Appraisals Committee of the Ontario Council on Graduate Studies.

In its academic programmes York University has placed strong emphasis on interdisciplinary studies and this emphasis is clearly reflected in the development of the Graduate Programmes in Chemistry, Physics and Space Science.

This University wishes to place on record its concern that the administratively convenient assessment of traditional disciplines should not obscure the academic arguments for further development of programmes which are not limited by artificial barriers and furthermore expresses the hope that new developments in graduate education and research will not be overlooked by undue adherence to the single discipline syndrome.

It is difficult to determine at some points in the report whether the figures given derive from academic or from manpower and resource considerations. If the total number of graduate students in Chemistry is to result in a "production" of 150 a year (p. A57), the figure of 30 on page A56, paragraph 3 seems a reasonable average in academic terms. On the other hand, 30 as a planning figure seems quite arbitrary: there would be circumstances in which a graduate department might operate efficiently with either a smaller or a larger number of students. Furthermore, York considers that it is the total population of graduate students and post-doctoral fellows that matters from an academic point of view and should be taken into consideration for long term planning purposes. York is particularly anxious to draw attention to this point because of the somewhat vague attitude to manpower and resource questions adopted by the consultants.

This is the University's response to the report of the ACAP consultants. York reserves the right to modify its response when ACAP itself reports to COU.

Yours sincerely,

Michael Collie,
Dean, Faculty of
Graduate Studies.

APPENDIX D

PROCEDURE OF PLANNING STUDY AND TERMS OF REFERENCE

BEST COPY AVAILABLE

Procedure for Chemistry Planning Assessment

19 January, 1972

A. Tasks Requested from Discipline Group (with help available from ACAP at all stages)

A.1. Prepare a list of major divisions and specialties within chemistry (January 28, 1972). This item will include a statement of the boundaries of the study, with biochemistry, physics, and engineering.

A.2. Suggest suitable consultants. This also will be a matter for discussion with ACAP. (list submitted, December 1971.)

A.3. Examine and comment on pro formae to be used for the gathering of information on current, past and future programmes as described in paragraph B.1. (January 19, 1972.)

A.4. Examine and comment on the adequacy of the data on current and past strength. (April 10, 1972 - April 30, 1972.)

A.5. Both in consultation with ACAP and separately, consider the situation revealed by the tabulation of proposed future programmes and consider whether future plans should be modified or developed in more detail. As a result of this step, individual universities may wish to revise the material described in B.1.d below. (April 10, 1972 - May 31, 1972.)

A.6. Possibly develop a tentative plan for development of established or new graduate work in chemistry in Ontario paying attention to adequate coverage of divisions of the discipline and specialties. Any such plans will be reported to ACAP which will transmit them to the consultants.

B. Information from Universities

B.1. Each university is asked to supply to ACAP, in the form indicated by ACAP after comment by the discipline group (paragraph A.3) information as follows:

a) for each major division determined in A.1, viz. biological chemistry, inorganic chemistry, physical chemistry, organic chemistry, analytical chemistry, theoretical chemistry:

(i) current list of faculty members showing fraction of research and graduate instruction time devoted to the division (for part-time professors show the time spent on university duties);

(ii) numbers of full-time and part-time faculty members for each of the past five years;

(iii) for the current year and preceding five years, number of (1) master's and (2) Ph.D. candidates and (3) post-doctoral fellows doing research in the division full and part-time shown separately.

Under these three headings one individual may appear under more than one category.

b) for each "department"

(i) Curricula Vitarum of each faculty member (Assistant Professors and higher) showing inter alia complete publication lists, research funding in the past five years, and students and post doctoral fellows supervised during his career, and specialization.

(ii) resources of space - a statement indicating the department's view of the adequacy of its space, and, in connection with the future plans in (d) below, discussing future space provision;

(iii) undergraduate base; honours and pass students, number of qualifying or make-up year students, student courses, number of courses taught, etc.;

(iv) other general items relevant to research and graduate study, a) major laboratories and equipment, over $5000, both departmental and extradepartmental b) computing facilities;

(v) support from related departments including shared teaching and research;

(vi) library resources: analysis of holdings and budget;

(vii) description of any inter-university arrangements for graduate work.

c) table of characteristics of graduate students in the department in previous five year, separately for master's and Ph.D., breaking down numbers by

(i) F.T. and P.T.;

(ii) immigration status (3 years) and country of first degree;

(iii) sources of financial support;

(iv) time to reach degree;

(v) drop-out number;

(vi) degrees granted;

(vii) post graduate employment of Ph.D.'s (a) immediate and (b) after two years.

d) proposed plans for the future, in as much detail as the department can provide, including the proposed scheme for support of these plans, and accompanied by supporting arguments, including consideration of the sources of graduate students and an analysis of demand for graduates from the programmes. The various headings in a) and b) above should be dealt with quantitatively where possible; as a minimum, planned numbers of faculty and graduate students should be given.

Items a) b) and c) are requested by March 24, 1972, and item d) by April 15, 1972.

B.2. The material so supplied will be collated by ACAP and transmitted to the discipline group by April 10, 1972 for action indicated in paragraphs A.4., A.5 and A.6.

B.3. Apart from the material described in B.1.d and to some extent generated at the department level, each interested university will be requested to make an individual statement on its plans for the development of chemistry, in particular the items of future commitment implied by item B.1.d. (May 31, 1972).

C. Terms of Reference of Consultants

C.1. Consider the materials prepared by the discipline group and the universities and obtain other data they may require to carry out the tasks detailed below. They may obtain data and views from any relevant source, such as, for example, employers of holders of graduate degrees, professional and learned societies, federal agencies. The campus of each interested university shall be visited by at least two consultants. Consultants shall arrange their schedule of visits to the universities in consultation with ACAP to ensure uniformity. Reports of appraisal consultants are privileged documents and are not to be made available to ACAP consultants. Consultants shall liaise with the discipline group near the beginning of the work, during the work as they consider necessary, and immediately before preparing their final report.

C.2. Report on the adequacy of the present state of graduate work in chemistry in the province in general and in each university where applicable, discussing the following:

a. coverage of core elements and specialties, and extent of activity in each.

b. faculty quality and quantity

c. nature of programmes offered

d. enrolment size and distribution amongst universities and divisions

e. quality of student body; admission requirements

f. relationship to related disciplines

g. physical facilities

h. other matters considered by the consultants to be significant.

C.3. Make recommendations for the development of graduate work in chemistry in Ontario between 1973 and 1983, but in more detail for 1973 through 1978, and, without limiting the generality of the foregoing, dealing with the following points:

a. Desirable programmes to be offered in the province, considering both possible limitations or reductions of existing programmes and creation of new programmes and new kinds of programmes including the appropriateness of part-time programmes. In particular, consider if there should or should not be more activity in fields of chemistry now producing few graduates in Ontario and also the desirability of developing application-oriented and interdisciplinary work in which chemistry should be involved.

b. Desirable provincial enrolments, year by year, in the various levels of graduate study and major subject divisions, and specialties where appropriate. One should consider the need for highly trained manpower and also the general cultural and societal factors which may lead students to pursue graduate work in chemistry. In considering manpower needs, one should take account of the "market" available to graduates (at least all of Canada) and of other sources of supply for that market. Results of forecasts of high level manpower employment should be treated with due caution and only in a clearly balanced relationship with cultural and societal needs.

c. Distribution amongst the universities of responsibility for programmes and for specialties where appropriate, including consideration of the need for any increase or decrease in the number of departments offering doctoral work and including consideration of areas of collaboration and sharing of facilities at regional level and across the province. Consider techniques for involvement in doctoral supervision of professors in departments which do not take doctoral students in their fields, and the extent to which such activity is desirable.

d. Distribution of enrolment amongst the universities, showing desirable ranges of enrolment.

e. Desirable extent of involvement with related disciplines. In particular consultants should note that biochemistry and geochemistry are not included in this assessment; they are asked to draw attention to any work in chemistry departments on a sufficient scale that it should be examined also when these disciplines are assessed. There will also be some work on the boundaries with physics, which they may treat similarly.

Due note should be taken of possible overlap in applied fields of chemistry with work in engineering departments.

In all cases, it is important that the rationale for the recommendations be clear; this is especially important for items c. and d.

C.4. It is permissible for consultants to recommend appraisals of individual programmes. This would arise if consultants were to suspect that a programme would be found to be wholly or in part below minimum acceptable standards; an appraisal by the Appraisals Committee is the means of settling the question. It is recognized that this action would be infrequent. Perhaps more likely, in planning assessments in some disciplines, consultants may find an excess of programmes in the same area of study, all of which could pass an appraisal; they would then have to make their own judgments of relative quality (a task outside the terms of reference of the Appraisals Committee), and guided by this judgment and other factors, the ACAP consultants would have to recommend where enrolment should be curtailed or eliminated.

D. Appointment of Consultants

The consultants shall include one person of wide academic experience in Canada but in a different discipline. The other three consultants shall be chemists of international standing with suitable administrative or consulting experience.

E. Report of Consultants

The consultants submit a joint report to ACAP (tentative date of December 15, 1972.) Minority reports are, of course, possible. The reasoning leading to their recommendations should be given fully, in view of the subsequent treatment of the report. The report is submitted for comment to the discipline group and to each interested university. There may be informal or interim exchanges of views amongst the discipline group, the universities, and ACAP. By February 1, 1973, any university which wishes to make a formal statement on the consultants' report shall submit it to ACAP. Any such report shall be transmitted to the discipline group. By February 15, 1973, the discipline group shall submit its formal comments and/or recommendations to ACAP. ACAP considers the discipline group and university statements along with the consultants' report and trasmits them to COU with its recommendations of the position COU should adopt (tentative date: March 15, 1973). Copies of the material transmitted to COU will be supplied to OCGS, to the Council of Deans of Arts and Science, and to the members of the discipline group and to the interested universities. The consultants' report may be published together with the comments of the discipline group, those of any university so requesting, and with the position adopted by COU.

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APPENDIX E

DISCIPLINE GROUP MEMBERSHIP

APPENDIX E

DISCIPLINE GROUP MEMBERSHIP

BROCK -	Professor M. S. Gibson until July 1, 1972 Professor R. Hiatt
CARLETON -	Professor J. M. Holmes
GUELPH -	Professor A. K. Colter
LAKEHEAD -	Professor S. Walker until May 30, 1972 Professor I. M. Hoodless
LAURENTIAN -	Father C. Allaire
McMASTER -	Professor R. H. Tomlinson
OTTAWA -	Professor H. H. Baer
QUEEN'S -	Professor R. D. Heyding
TORONTO -	Professor A. G. Brook
TRENT -	Professor G. O. Aspinall until August 10, 1972 Professor K. B. Oldham
WATERLOO -	*Professor W. A. E. McBryde
WESTERN ONTARIO -	Professor H. C. Clark until July 1, 1972 Professor J. Brand
WINDSOR -	Dr. G. W. Wood until August 22, 1972 Dr. D. G. Tuck
YORK -	Professor H. O. Pritchard until May 19, 1972 Professor G. O. Aspinall

* Chairman of Discipline Group

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APPENDIX F

ROLES OF ACAP AND OF DISCIPLINE GROUPS

Ontario Council on Graduate Studies

By-Law No. 3

A By-Law to establish a Committee on the Academic Planning of Graduate Studies.

1. The Ontario Council on Graduate Studies, recognizing the importance of providing for the continued and orderly development of graduate studies in the Ontario universities, establishes a Standing Committee to be known as the Advisory Committee on Academic Planning (abbreviation - ACAP).

Interpretation

2. In this By-Law,

   (a) "Committee" without further specification, means the Advisory Committee on Academic Planning;

   (b) "Council" or OCGS means the Ontario Council on Graduate Studies;

   (c) "Committee of Presidents" or CPUO means the Committee of Presidents of Universities of Ontario;

   (d) "university" means a provincially assisted university in Ontario;

   (e) "discipline" means any branch or combination of branches of learning so designated;

   (f) "discipline group" means a body designated as such by the Committee of Presidents of the Universities of Ontario, and normally consisting, for any one discipline, of one representative from each of the interested universities;

   (g) "planning assessment" means a formal review of current and projected graduate programmes within a discipline or a group of disciplines;

   (h) "programme" signifies all aspects of a particular graduate undertaking;

   (i) "rationalization" means the arranging of graduate programmes in order to avoid undesirable duplication, eliminate waste, and enhance and sustain quality.

Membership

3. (a) The Committee shall consist of at least seven members of the professoriate in Ontario universities, some of whom shall be members of the Council.

(b) The members of the Committee shall serve for such periods of time as the Council may determine, and they shall be selected in such manner as may provide for reasonable balance both of academic disciplines and of universities

(c) The members of the Committee shall be appointed as individuals.

Chairman

4. The Chairman of the Committee shall be named by the Council, and he shall have one vote.

Quorum

5. A majority of all members of the Committee shall constitute a quorum.

Functions

6. The functions of the committee shall be

(a) To advise OCGS on steps to be taken to implement effective provincial planning of graduate development;

(b) To promote the rationalization of graduate studies within the universities, in cooperation with the discipline groups;

(c) To recommend, through OCGS, to CPUO the carrying out of planning assessments of disciplines or groups of disciplines and to recommend suitable arrangements and procedures for each assessment;

(d) To supervise the conduct of each planning assessment approved by CPUO;

(e) To respond to requests by CPUO to have a discipline assessment conducted by proposing suitable arrangements;

(f) To submit to CPUO the reports of the assessments together with any recommendations which the committee wishes to make. A copy of the report shall be sent to Council.

Jurisdiction

7. In order that the Committee may discharge the functions described in Section 6 above, it shall be authorized

   (a) to request a university to provide such information pertaining to graduate studies as may enable the Committee to discharge its functions;

   (b) to request a discipline group to provide such information as may enable the Committee to discharge its functions;

   (c) to receive reports from the universities and from the discipline groups, and to comment and communicate with the universities and the discipline groups concerning such reports;

   (d) to convene a meeting of any discipline group for the purpose of discussing the development to date, and proposals for the future development of graduate studies in the discipline concerned;

   (e) to send one or more representatives to a meeting of a discipline group at the invitation of the discipline group;

   (f) to make such suggestions to a discipline group as may be deemed appropriate to the functions of the Committee;

   (g) to supervise the conduct of planning assessments, and to report thereon to the Committee of Presidents of Universities of Ontario;

   (h) generally to report and to make recommendations to the Council;

   (i) to seek and receive advice from appropriate experts;

   (j) to employ consultants in connection with planning assessments.

Procedures

8. The procedure to be followed by the Committee shall be as approved by the Committee of Presidents of the University of Ontario.

9. The Committee's function is solely advisory.

Effective Date

10. This By-Law shall take effect January 1971.

ACAP DISCIPLINE GROUPS AND THEIR ROLES

1. Establishment of a Group

a. When it is considered desirable to activate planning of graduate work in some discipline(s) or interdisciplinary area, COU, on the advice of OCGS, will authorize the establishment of an ACAP discipline group, if it was not already approved and included in the May, 1968 list. If it is already authorized, ACAP may decide to set it up as described in paragraph b.

b. The Executive Vice-Chairman of ACAP will then invite the executive head of each university (including Wilfrid Laurier University) either to nominate a member of the discipline group or to indicate that his university has no plans for graduate study in this discipline in the next five years or so. If a university can state no plans for future graduate work in the subject, but feels that a watching brief is desirable, it may appoint an observer to the group.

c. Changes of a university's representative are to be notified by the executive head.

d. The group shall select its own chairman.

2. Meetings

a. A discipline group may meet at the call of its chairman or in accord with its own arrangements.

b. A discipline group may be called to meet by the Executive Vice-Chairman acting for ACAP.

3. Responsibilities

a. The group is to keep under review the plans for graduate work in its discipline in Ontario, including new developments and trends in the discipline, and to make reports to ACAP on a regular basis.

b. The group may make recommendations to ACAP in connection with graduate work in its discipline when it considers it appropriate.

c. ACAP will assist the group in obtaining information and data, as mutually agreed.

d. When COU has instructed ACAP to conduct a planning assessment, the discipline group will assist and advise ACAP in determining procedures and terms of reference, will report as requested and will generally facilitate the assessment.

Approved by OCGS March 22, 1973
and by COU April 6, 1973.

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APPENDIX G

CURRICULA VITARUM OF THE CONSULTANTS

FRED BASOLO

Born Coello, Illinois, February 11, 1920

B.Ed., Southern Illinois Normal University, 1940
M.S., Illinois, 1942
Ph.D., Illinois, 1943

Research Chemist, Rohm and Haas Chemical Co., 1943-46
Northwestern University, Instructor in Chemistry 1946-48
Assistant Professor 1948-53
Associate Professor 1953-59
Professor 1959-
Chairman of Department 1969-

Guggenheim Fellow 1954-58
National Science Foundation Senior Fellow 1961-62
Award of the American Chemical Society 1964

Co-ordination compounds; reaction mechanisms of inorganic complex compounds; metal nitrenes; synthetic oxygen - carriers.

Address: Department of Chemistry
Northwestern University
Evanston, Illinois

RAYMOND U. LEMIEUX

Born Lac la Biche, Alberta, June 16, 1920

B.Sc., Alberta, 1943
Ph.D., McGill, 1946
D.Sc., U.N.B. 1967; Laval, 1970

Ohio State University, Research Associate, 1946-47
University of Saskatchewan, Assistant Professor, 1947-49
Research Officer, Prairie Regional Laboratory, National Research Council, 1949-54
University of Ottawa, 1954-61: Professor of Chemistry, Chairman of Department,
Vice Dean of the Faculty of Pure and Applied Science
University of Alberta, Professor of Organic Chemistry, 1961-
President and Director of Research, Raylo Chemical Ltd., Alberta

Medal of Service, Order of Canada 1968
Fellow of the Royal Society of London
Fellow the Royal Society of Canada

Merck Lecturer 1956
Folkers Lecturer 1958
Medal of the Chemical Institute of Canada 1964
C. S. Hudson Award, American Chemical Society, 1966
Karl Pfister Lecturer 1968
Purves Lecturer 1970

Sterochemistry; conformational analysis; carbohydrate chemistry; chemistry of natural products, especially antibiotics; mechanisms of organic replacement and oxidation reactions.

Address: Department of Chemistry
University of Alberta
Edmonton, Alberta

W. ALBERT NOYES, Jr.

Born Terre Haute, Indiana, April 18, 1898

A.B., Grinnell College, 1919
D.es Sc., Paris, 1920
D.Sc., Grinnell, Paris Rhode Island, Indiana, Ottawa, Montreal, Illinois, Rochester, Carleton

2nd Lt., U.S.A. Signal Corps, 1917-19

University of California, Instructor 1921-22
University of Chicago, Assistant Professor and Associate Professor, 1922-29
Brown University, Associate Professor and Professor, 1929-38
University of Rochester, Professor 1938-63, Chairman of Department 1939-55
Dean of Graduate Studies, 1952-55,
Dean of College of Arts and Science 1956-58
University of Texas at Austin, Ashbel Smith Professor of Chemistry 1963-
Senior scientist emeritus, Argonne National Laboratory 1963-72

Medal for Merit, 1948
King's Medal of Service in the Cause of Freedom, 1948
Officer, Legion of Honour, 1954

Member of the National Academy of Sciences
President of the American Chemical Society, 1947
Fellow of the American Physical Society
Member of the Faraday Society
Member of the American Philosophical Society
Honorary member of the Chemical Society of France
Honorary member of the Royal Spanish Society of Physics and Chemistry
Corresponding member of the National Academy of Sciences of Portugal

Daines Lecturer (University of Kansas)
Montgomery Lecturer (University of Nebraska)
Westmann Memorial Lecturer (Chemical Institute of Canada)
Priestley Medal, ACS, 1953
Gibbs Medal, ACS, 1957
Charles L. Parsons Award, ACS, 1970

National Defense Research Committee 1940-42
Office of Scientific Research and Development 1942-46
Advisory Committee office of Naval Research 1947-52

International Union of Pure and Applied Chemistry, Vice President 1947-51 and President 1959-63
Division Chairman, National Research Council 1947-53
Trustee, Sloan-Kettering Institute for Career Research 1948-63
International Council of Scientific Unions, Treasurer 1952-55

Electrochemistry; photochemistry; vapor pressures; reaction kinetics; fluorescence, spectroscopy

Address: Department of Chemistry
University of Texas
Austin, Texas

G. M. VOLKOFF

Born Moscow, Russia, February 23, 1914

B.A., British Columbia, 1934
M.A., British Columbia, 1936
Ph.D., California, 1940
D.Sc., British Columbia

University of British Columbia, Assistant Professor, 1940-43
Montreal Laboratory, National Research Council of Canada, Associate Research Physicist and Head of Theoretical Physics Branch 1945-46
University of British Columbia, Professor 1946-, Head of Department of Physics 1961-72, Dean of the Faculty of Science, 1971-.

Member of the Order of the British Empire 1946

Fellow of the Royal Society of Canada
Fellow of the American Physical Society
President of the Canadian Association of Physicists, 1962-63
Editor, Canadian Journal of Physics, 1950-56
Member of the National Research Council of Canada, 1969-

Theoretical nuclear physics; neutron diffusion; nuclear magnetic and quadrupole resonance

Address: Faculty of Science,
University of British Columbia
Vancouver 8, British Columbia